JAPAN PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 3, 2003

Application Number: Patent Application No. 2003-404384

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is JP 2003-404384

Applicant(s): NIKON CORPORATION

March 17, 2006

Commissioner, Japan Patent Office

Makoto NAKAJIMA

Certificate Issuance No. 2006-3019990

[Title of the Document] Patent Application

[Reference Number] J15428A1

[Filing Date] December 3, 2003

[Attention] To Commissioner, Patent Office

[IPC] H01L 21/027

[Inventor]

[Address or Domicile]

c/o NIKON CORPORATION

2-3, Marunouchi 3-chome,

Chiyoda-ku, Tokyo

[Name] Hiroyuki NAGASAKA

[Inventor]

[Address or Domicile]

c/o NIKON CORPORATION

2-3, Marunouchi 3-chome,

Chiyoda-ku, Tokyo

[Name] Hiroaki TAKAIWA

[Inventor]

[Address or Domicile]

c/o NIKON CORPORATION

2-3, Marunouchi 3-chome,

Chiyoda-ku, Tokyo

[Name] Shigeru HIRUKAWA

[Applicant]

[Identified Number] 000004112

[Name or Appellation] NIKON CORPORATION

[Agent of the Applicant]

[Identified Number] 100064908

[Patent Attorney]

[Name or Appellation] Masatake SHIGA

[Appointed Agent of the Applicant]

[Identified Number] 100108578

[Patent Attorney]

[Name or Appellation] Norio TAKAHASHI

[Appointed Agent of the Applicant]

[Identified Number] 100101465

[Patent Attorney]

[Name or Appellation] Masakazu AOYAMA

[Appointed Agent of the Applicant]

[Identified Number] 100107836

[Patent Attorney]

[Name or Appellation] Kazuya NISHI

[Indication of charge]

[Serial number for pre-paid] 008707

[Amount of payment] 21,000yen

[List of filing documents]

[Name of Document] Claims 1

[Name of Document] Specification 1

[Name of Document] Drawing 1

[Name of Document] Abstract 1

[Serial Number of General Power of Attorney] 9800076

INFORMATION ON APPLICANT'S HISTORY

Identified Number [000004112]

1.	Date of change	August 29, 1990
	[Reason for change]	New registration
	Address	2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo
	Name	NIKON CORPORATION

[TITLE OF THE DOCUMENT] CLAIMS

[Claim 1] An exposure apparatus which exposes a substrate by radiating an exposure light beam onto the substrate via a projection optical system and a liquid, the exposure apparatus characterized by comprising a substrate table which holds the substrate, wherein the substrate table has an exchangeable member, at least a part of a surface of which is liquid-repellent.

[Claim 2] The exposure apparatus according to claim 1, characterized in that the member is exchanged depending on deterioration of liquid repellence thereof.

[Claim 3] The exposure apparatus according to claim 1 or 2, characterized in that the member has a flat portion which is substantially flush with a surface of the substrate held by the substrate table.

[Claim 4] The exposure apparatus according to claim 3, characterized in that the flat portion is arranged around the substrate.

[Claim 5] The exposure apparatus according to claim 4, characterized by comprising an attaching/detaching mechanism which attaches/detaches the member with respect to the substrate table.

[Claim 6] The exposure apparatus according to claim 5, characterized in that the attaching/detaching mechanism is capable of detaching the member from the substrate table together with the substrate.

[Claim 7] The exposure apparatus according to any one of claims 1 to 6, characterized in that at least the liquid-repellent part of the member is polytetrafluoroethylene.

[Claim 8] A method for producing a device, characterized by using the exposure apparatus as defined in any one of claims 1 to 7.

[Claim 9] An exposure method for performing liquid immersion exposure for a substrate by radiating an exposure light beam onto the substrate via a projection optical system and a liquid, the exposure method characterized by comprising:

holding the substrate with a substrate-holding member, the substrate-holding member having a flat portion which is disposed around the substrate and which is substantially flush with a surface of the substrate;

loading the substrate-holding member to a substrate stage, the substrate-holding member holding the substrate;

performing the liquid immersion exposure for the substrate loaded onto the substrate stage; and

unloading the substrate-holding member with which the substrate is held from the substrate stage after completion of the liquid immersion exposure.

[Claim 10] The exposure method according to claim 9, characterized in that a surface of the flat portion of the substrate-holding member is liquid-repellent.

[Claim 11] A method for producing a device, characterized by using the exposure method as defined in claim 9 or 10.

[TITLE OF THE DOCUMENT] Specification

[TITLE OF THE INVENTION] EXPOSURE APPARATUS, EXPOSURE METHOD, AND METHOD FOR PRODUCING DEVICE

[TECHNICAL FIELD]

[0001] The present invention relates to an exposure apparatus, an exposure method, and a method for producing a device, in which an exposure light beam is radiated onto a substrate via a projection optical system and a liquid to expose the substrate.

[BACKGROUND ART]

[0002] Semiconductor devices and liquid crystal display devices are produced by means of the so-called photolithography technique in which a pattern formed on a mask is transferred onto a photosensitive substrate. The exposure apparatus, which is used in the photolithography step, includes a mask stage for supporting the mask and a substrate stage for supporting the substrate. The pattern on the mask is transferred onto the substrate via a projection optical system while successively moving the mask stage and the substrate stage. In recent years, it is demanded to realize the higher resolution of the projection optical system in order to respond to the further advance of the higher integration of the device pattern. As the exposure wavelength to be used is shorter, the resolution of the projection optical system becomes higher. As the numerical aperture of the projection optical system is

larger, the resolution of the projection optical system becomes higher. Therefore, the exposure wavelength, which is used for the exposure apparatus, is shortened year by year, and the numerical aperture of the projection optical system is increased as well. The exposure wavelength, which is dominantly used at present, is 248 nm of the KrF excimer laser. However, the exposure wavelength of 193 nm of the ArF excimer laser, which is shorter than the above, is also practically used in some situations. When the exposure is performed, the depth of focus (DOF) is also important in the same manner as the resolution. The resolution R and the depth of focus δ are represented by the following expressions respectively.

$$R = k_1 \bullet \lambda / NA \quad \ldots(1)$$

$$\delta = \pm k_2 \bullet \lambda / NA^2 \quad \ldots(2)$$

In the expressions, λ represents the exposure wavelength, NA represents the numerical aperture of the projection optical system, and k_1 and k_2 represent the process coefficients. According to the expressions (1) and (2), the following fact is appreciated. That is, when the exposure wavelength λ is shortened and the numerical aperture NA is increased in order to enhance the resolution R, then the depth of focus δ is narrowed.

[0003] If the depth of focus δ is too narrowed, it is difficult to match the substrate surface with respect to

the image plane of the projection optical system. It is feared that the margin is insufficient during the exposure operation. In view of the above, the liquid immersion method has been suggested, which is disclosed, for example, in the following Patent Document 1, as a method for substantially shortening the exposure wavelength and widening the depth of focus. In this liquid immersion method, the space between the lower surface of the projection optical system and the substrate surface is filled with a liquid such as water or any organic solvent to form a liquid immersion area so that the resolution is improved and the depth of focus is magnified about n times by utilizing the fact that the wavelength of the exposure light beam in the liquid is 1/n as compared with that in the air (n represents the refractive index of the liquid, which is about 1.2 to 1.6 in ordinary cases).

[Patent Document 1] Pamphlet of International Publication No. 99/49504

[DISCLOSURE OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0004] As schematically shown in Fig. 18, in addition to the exposure process for shot areas SH disposed in the vicinity of the center of the substrate P as wafer, an edge area E of the substrate P is sometimes subjected to the exposure in a state that the edge area E of the substrate P is included in a projection area 100 of a projection

optical system. For example, the following situations can occur. By performing the exposure procedure for the edge area E of the substrate P to form a pattern as well, it is possible to prevent the substrate P from abutting against a polishing surface of a CMP apparatus in an unbalanced manner in a CMP (chemical mechanical polishing) process as a downstream step. Alternatively, in order to utilize the substrate P more effectively, a small device pattern is formed on the edge area E as well. In such a situation, a portion of the projection area 100 protrudes to the outside of the substrate P, and the exposure light beam is also radiated onto a substrate table 120 for holding the substrate P. In the case of the liquid immersion exposure, the liquid immersion area of the liquid is formed so that the projection area 100 is covered therewith. However, when the edge area E is subjected to the exposure, then a part of the liquid immersion area of the liquid protrudes to the outside of the substrate P, and the liquid immersion area is disposed on the substrate table 120 in a similar manner to the projection area 100. Although not shown in Fig.18, various measuring members and/or measuring sensors are arranged around the substrate P on the substrate table 120. When these measuring members and/or measuring sensors are used, the liquid immersion area is also disposed on the substrate table 120 in some cases. When a portion of the liquid immersion area is disposed on the substrate table

120, then the liquid may remain on the substrate table 120 highly possibly, and the following possibility arises. That is, for example, the environment (temperature, humidity), in which the substrate P is placed, may be varied as a result of the vaporization of the remained liquid, the substrate P and the substrate table 120 may be thermally deformed, the optical paths for various measuring light beams to measure, for example, the position information about the substrate P may be varied, and the exposure accuracy may be deteriorated. Further, the following possibility arises as well. That is, the water mark (trace of water) may remain after the vaporization of the remained liquid, which may result in the factor of the error concerning various types of measurements. Therefore, it is preferable that at least the surface of the substrate table 120 which makes contact with the liquid is liquid-repellent in order to prevent the liquid from remaining on the substrate table 120. Even when the liquid remains, the liquid can be easily recovered by providing the liquid-repellence of the substrate table 120. However, When the liquid-repellent material is coated, or the substrate table 120 is formed of the liquid-repellent material in order to provide the liquid repellence of the substrate table 120, then the liquid repellence thereof is deteriorated in some cases when the exposure light beam is radiated. In particular, for example, when the fluorine-based resin is

used as the liquid-repellent material, and the ultraviolet light is used as the exposure light beam, then the liquid repellence of the substrate table tends to be deteriorated (tends to become lyophilic or liquid-attractive). In such a situation, the liquid tends to remain on the substrate table, which results in the deterioration of the exposure accuracy and the measurement accuracy.

[0005] The present invention has been made taking the foregoing circumstances into consideration, an object of which is to provide an exposure apparatus, an exposure method, and a method for producing a device, in which it is possible to prevent the liquid from remaining on the substrate table, and it is possible to maintain a satisfactory exposure accuracy and a satisfactory measurement accuracy.

[MEANS FOR SOLVING THE PROBLEM]

[0006] In order to achieve the objects as described above, the present invention adopts the following constructions corresponding to Figs. 1 to 17 as illustrated in embodiments.

The exposure apparatus of the present invention is an exposure apparatus (EX) which exposes a substrate (P) by radiating an exposure light beam (EL) onto the substrate (P) via a projection optical system (PL) and a liquid (1), the exposure apparatus characterized by comprising a substrate table (PT) which holds the substrate (P), wherein

the substrate table (PT) has an exchangeable member (30), at least a part of a surface (30A) of which is liquid-repellent.

A method for producing a device according to the present invention is characterized by using the exposure apparatus described above.

[0007] According to the present invention, the liquid-repellent member, which is provided on the substrate table, is provided exchangeably. Therefore, when the liquid repellence of the member is deteriorated, the liquid repellence on the substrate table can be maintained by merely exchanging the member with a new member.

Therefore, it is possible to suppress the remaining of the liquid on the substrate table. Even when the liquid remains, the liquid can be recovered smoothly. Therefore, it is possible to avoid the deterioration of the exposure accuracy and the measurement accuracy which would be otherwise caused by the remaining liquid. It is possible to produce the device which can exhibit desired performance.

[0008] The exposure method of the present invention is an exposure method for performing liquid immersion exposure for a substrate (P) by radiating an exposure light beam (EL) onto the substrate (P) via a projection optical system (PL) and a liquid (1), the exposure method characterized by comprising: holding the substrate (P) with a substrate-

holding member (30), the substrate-holding member (30) having a flat portion (30A) which is disposed around the substrate (P) and which is substantially flush with a surface of the substrate (P); loading the substrate-holding member (30) to a substrate stage (PST, PT), the substrate-holding member (30) holding the substrate (P); performing the liquid immersion exposure for the substrate (P) loaded onto the substrate stage (PST, PT); and unloading the substrate-holding member (30) with which the substrate (P) is held from the substrate stage (PST, PT) after completion of the liquid immersion exposure.

A method for producing a device according to the present invention is characterized by using the exposure method described above.

[0009] According to the present invention, the substrate-holding member, which has the flat portion around the substrate, is loaded and unloaded with respect to the substrate stage together with the substrate. Accordingly, the substrate-holding member can be easily exchanged with respect to the substrate stage together with the substrate. For example, even when the liquid repellence of the substrate-holding member is deteriorated, it is easy to perform the exchange. The substrate-holding member has the flat portion around the substrate. Therefore, when the substrate-holding member is loaded to the substrate stage together with the substrate, and the liquid immersion

exposure for the edge area of the substrate is performed, the shape of the liquid immersion area is maintained by the flat portion, even when a part of the liquid immersion area of the liquid protrudes to the outside of the substrate. It is possible to perform the liquid immersion exposure in a state in which the liquid is satisfactorily retained below the projection optical system, without causing, for example, the outflow of the liquid. Therefore, the deterioration of the exposure accuracy is avoided, and it is possible to produce the device which exhibits desired performance.

[EFFECTS OF THE INVENTION]

[0010] According to the present invention, even when the edge area of the substrate is subjected to the exposure, it is possible to perform the exposure process while suppressing the outflow of the liquid, and it is possible to avoid the remaining of the liquid on the substrate table. Therefore, the liquid immersion exposure can be performed at the high exposure accuracy.

[BEST MODE FOR CARRYING OUT THE INVENTION]

[0011] An explanation will be made below about the exposure apparatus according to the present invention with reference to the drawings. Fig. 1 shows a schematic arrangement illustrating an embodiment of the exposure apparatus of the present invention.

With reference to Fig. 1, an exposure apparatus EX

includes a mask stage MST which supports a mask M, a substrate stage PST which supports a substrate P by the aid of a substrate table PT, an illumination optical system IL which illuminates, with an exposure light beam EL, the mask M supported by the mask stage MST, a projection optical system PL which performs projection exposure for the substrate P supported by the substrate stage PST with an image of a pattern of the mask M illuminated with the exposure light beam EL, and a control unit CONT which integrally controls the overall operation of the exposure apparatus EX.

[0012] The liquid immersion method is applied to the exposure apparatus EX of the embodiment of the present invention in order that the exposure wavelength is substantially shortened to improve the resolution and the depth of focus is substantially widened. The liquid immersion exposure apparatus includes a liquid supply mechanism 10 which supplies the liquid 1 onto the substrate P, and a liquid recovery mechanism 20 which recovers the liquid 1 from the surface of the substrate P. In embodiment of the present invention, pure water is used as the liquid 1. The exposure apparatus EX forms a liquid immersion area AR2 (locally) on at least a part of the substrate P including a projection area AR1 of the projection optical system PL by the liquid 1 supplied from the liquid supply mechanism 10 at least during the period

in which the image of the pattern of the mask M is transferred onto the substrate P. Specifically, the exposure apparatus EX is operated as follows. That is, the space between the surface (exposure surface) of the substrate P and the optical element 2 disposed at the end portion of the projection optical system PL is filled with the liquid 1. The image of the pattern of the mask M is projected onto the substrate P to expose the substrate P therewith via the projection optical system PL and the liquid 1 disposed between the projection optical system PL and the substrate P.

[0013] The embodiment of the present invention will now be explained as exemplified by a case of the use of the scanning type exposure apparatus (so-called scanning stepper) as the exposure apparatus EX in which the substrate P is exposed with the pattern formed on the mask M while synchronously moving the mask M and the substrate P in mutually different directions (opposite directions) in the scanning directions. In the following explanation, the Z axis direction is the direction which is coincident with the optical axis AX of the projection optical system PL, the X axis direction is the synchronous movement direction (scanning direction) for the mask M and the substrate P in the plane perpendicular to the Z axis direction, and the Y axis direction (non-scanning direction) is the direction which is perpendicular to the Z axis direction and the Y

axis direction. The directions of rotation (inclination) about the X axis, the Y axis, and the Z axis are designated as θX, θY, and θZ directions respectively. The term "substrate" referred to herein includes those obtained by coating a semiconductor wafer surface with a photoresist as a photosensitive material, and the term "mask" includes a reticle formed with a device pattern to be subjected to the reduction projection onto the substrate.

[0014] The illumination optical system IL is used so that the mask M, which is supported on the mask stage MST, is illuminated with the exposure light beam EL. The illumination optical system IL includes, for example, an exposure light source, an optical integrator which uniformizes the illuminance of the light flux radiated from the exposure light source, a condenser lens which collects the exposure light beam EL emitted from the optical integrator, a relay lens system, and a variable field diaphragm which sets the illumination area on the mask M illuminated with the exposure light beam EL to be slit-shaped. The predetermined illumination area on the mask M is illuminated with the exposure light beam EL having a uniform illuminance distribution by the illumination optical system IL. Those usable as the exposure light beam EL radiated from the illumination optical system IL include, for example, emission lines (g-ray, h-ray, i-ray) in the ultraviolet region radiated, for example, from a

mercury lamp, far ultraviolet light beams (DUV light beams) such as the KrF excimer laser beam (wavelength: 248 nm), and vacuum ultraviolet light beams (VUV light beams) such as the ArF excimer laser beam (wavelength: 193 nm) and the F_2 laser beam (wavelength: 157 nm). In this embodiment, the ArF excimer laser beam is used. As described above, the liquid 1 is pure water in this embodiment, through which the exposure light beam EL is transmissive even when the exposure light beam EL is the ArF excimer laser beam. The emission line (g-ray, h-ray, i-ray) in the ultraviolet region and the far ultraviolet light beam (DUV light beam) such as the KrF excimer laser beam (wavelength: 248 nm) are also transmissive through pure water.

[0015] The mask stage MST supports the mask M, while the mask stage MST is two-dimensionally movable in the plane perpendicular to the optical axis AX of the projection optical system PL, i.e., in the XY plane, and it is finely rotatable in the θZ direction. The mask stage MST is driven by a mask stage-driving unit MSTD such as a linear motor. The mask stage-driving unit MSTD is controlled by the control unit CONT. A movement mirror 50 is provided on the mask stage MST. A laser interferometer 51 is provided at a position opposed to the movement mirror 50. The position in the two-dimensional direction and the angle of rotation of the mask M on the mask stage MST are measured in real-time by the laser interferometer 51. The result of

the measurement is outputted to the control unit CONT. The control unit CONT drives the mask stage-driving unit MSTD on the basis of the result of the measurement obtained by the laser interferometer 51 to thereby position the mask M supported on the mask stage MST.

[0016] The projection optical system PL projects the pattern on the mask M onto the substrate P at a predetermined projection magnification β to perform the exposure. The projection optical system PL includes a plurality of optical elements including the optical element (lens) 2 provided at the end portion on the side of the substrate P. The optical elements are supported by a barrel PK. In this embodiment, the projection optical system PL is based on the reduction system having the projection magnification β which is, for example, 1/4 or 1/5. The projection optical system PL may be any one of the 1x magnification system and the magnifying system. The optical element 2, which is disposed at the end portion of the projection optical system PL of this embodiment, is provided detachably (exchangeably) with respect to the barrel PK. The liquid 1 in the liquid immersion area AR2 makes contact with the optical element 2.

[0017] The optical element 2 is formed of fluorite. Fluorite has a high affinity for water. Therefore, the liquid 1 is successfully allowed to make tight contact with the substantially entire surface of the liquid contact

surface 2a of the optical element 2. That is, in this embodiment, the liquid (water) 1, which has the high affinity for the liquid contact surface 2a of the optical element 2, is supplied. Therefore, the highly tight contact is effected between the liquid 1 and the liquid contact surface 2a of the optical element 2. The optical path, which is disposed between the optical element 2 and the substrate P, can be reliably filled with the liquid 1. The optical element 2 may be quartz having a high affinity for water as well. A water-attracting (lyophilic or liquid-attracting) treatment may be performed to the liquid contact surface 2a of the optical element 2 to further enhance the affinity for the liquid 1. The barrel PK makes contact with the liquid (water) 1 at portions disposed in the vicinity of the end portion. Therefore, at least the portions disposed in the vicinity of the end portion are formed of a metal such as Ti (titanium) which has the resistance against rust.

[0018] The substrate stage PST supports the substrate P. The substrate stage PST includes a Z stage 52 which holds the substrate P by the aid of the substrate table PT, an XY stage 53 which supports the Z stage 52, and a base 54 which supports the XY stage 53. The substrate table PT holds the substrate P. The substrate table PT is provided on the substrate stage PST (Z stage 52). The substrate stage PST is driven by a substrate stage-driving unit PSTD such as a

linear motor. The substrate stage-driving unit PSTD is controlled by the control unit CONT. By driving the Z stage 52, the substrate P held by the substrate table PT is subjected to the control of the position in the Z axis direction (focus position) and the positions in the θX and θY directions. By driving the XY stage 53, the substrate P is subjected to the control of the position in the XY directions (position in the direction substantially parallel to the image plane of the projection optical system PL). That is, the Z stage 52 controls the focus position and the angle of inclination of the substrate P so that the surface of the substrate P is adjusted to match the image plane of the projection optical system PL in the auto-focus manner and the auto-leveling manner, and the XY stage 53 positions the substrate P in the X axis direction and the Y axis direction. It goes without saying that the Z stage and the XY stage may be provided as an integrated body. Those usable for the auto-focus/auto-leveling detecting system include, for example, an arrangement disclosed in Japanese Patent Application Laid-open No. 8-37149.

[0019] A movement mirror 55 is provided on the substrate stage PST (substrate table PT). A laser interferometer 56 is provided at a position opposed to the movement mirror 55. The angle of rotation and the position in the two-dimensional direction of the substrate P on the substrate

stage PST (substrate table PT) are measured in real-time by the laser interferometer 56. The result of the measurement is outputted to the control unit CONT. The control unit CONT drives the substrate stage-driving unit PSTD on the basis of the result of the measurement of the laser interferometer 56 to thereby position the substrate P supported on the substrate stage PST.

[0020] A substrate alignment system 350, which detects the alignment mark on the substrate P or the reference mark (described later on) provided on the substrate table PT, is arranged in the vicinity of the substrate table PT. A mask alignment system 360, which detects the reference mark provided on the substrate table PT via the mask M and the projection optical system PL, is provided in the vicinity of the mask stage MST. Those usable for the arrangement of the substrate alignment system 350 include, for example, one disclosed in Japanese Patent Application Laid-open No. 4-65603. Those usable for the arrangement of the mask alignment system 360 include, for example, one disclosed in Japanese Patent Application Laid-open No. 7-176468.

[0021] A plate member 30, which surrounds the substrate P held by the substrate table PT, is provided on the substrate table PT. The plate member 30 is a member distinct from the substrate table PT. The plate member 30 is provided detachably with respect to the substrate table PT, and the plate member 30 is exchangeable. The plate

member 30 has a flat surface (flat portion) 30A which is substantially flush with the surface of the substrate P held by the substrate table PT. The flat surface 30A is arranged around the substrate P held by the substrate table PT. Further, a second plate member 32, which has a flat surface 32A substantially flush with the flat surface 30A of the plate member 30, is provided outside the plate member 30 on the substrate table PT. The second plate member 32 is provided detachably with respect to the substrate table PT as well, and the second plate member 32 is exchangeable.

[0022] The liquid supply mechanism 10, which supplies the predetermined liquid 1 onto the substrate P, includes a first liquid supply section 11 and a second liquid supply section 12 which are capable of supplying the liquid 1, a first supply member 13 which is connected to the first liquid supply section 11 via a supply tube 11A having a flow passage and which has a supply port 13A for supplying the liquid 1 fed from the first liquid supply section 11 onto the substrate P, and a second supply member 14 which is connected to the second liquid supply section 12 via a supply tube 12A having a flow passage and which has a supply port 14A for supplying the liquid 1 fed from the second liquid supply section 12 onto the substrate P. The first and second supply members 13, 14 are arranged closely to the surface of the substrate P, and they are provided at

mutually different positions in the surface direction of the substrate P. Specifically, the first supply member 13 of the liquid supply mechanism 10 is provided on one side (-X side) in the scanning direction with respect to the projection area AR1. The second supply member 14 is provided on the other side (+X side).

[0023] Each of the first and second liquid supply sections 11, 12 includes, for example, a tank for accommodating the liquid 1, and a pressurizing pump. The first and second liquid supply sections 11, 12 supply the liquid 1 onto the substrate P via the supply tubes 11A, 12A and the supply members 13, 14 respectively. The operation of each of the first and second liquid supply sections 11, 12 for supplying the liquid is controlled by the control unit CONT. The control unit CONT is capable of controlling the liquid supply amounts per unit time onto the substrate P by the first and second liquid supply sections 11, 12 independently respectively. Each of the first and second liquid supply sections 11, 12 includes a temperature-adjusting mechanism for the liquid, and thus the liquid 1, which has approximately the same temperature (for example, 23 °C) as the temperature in the chamber for accommodating the apparatus therein, is supplied onto the substrate P.

[0024] The liquid recovery mechanism 20 recovers the liquid 1 from the surface of the substrate P. The liquid recovery mechanism 20 includes first and second recovery

members 23, 24 each of which has a recovery port 23A, 24A arranged closely to the surface of the substrate P, and first and second liquid recovery sections 21, 22 which are connected to the first and second recovery members 23, 24 via recovery tubes 21A, 22A having flow passages respectively. Each of the first and second liquid recovery sections 21, 22 includes, for example, a vacuum system (sucking unit) such as a vacuum pump, a gas/liquid separator, and a tank for accommodating the recovered liquid 1. The first and second liquid recovery sections 21, 22 recover the liquid 1 from the surface of the substrate P via the first and second recovery members 23, 24 and the recovery tubes 21A, 22A, respectively. The operation of each of the first and second liquid recovery sections 21, 22 for recovering the liquid is controlled by the control unit CONT. The control unit CONT is capable of controlling the liquid recovery amounts per unit time by the first and second liquid recovery sections 21, 22 respectively.

[0025] Fig. 2 shows a plan view illustrating a schematic arrangement of the liquid supply mechanism 10 and the liquid recovery mechanism 20. As shown in Fig. 2, the projection area AR1 of the projection optical system PL is designed to have a slit shape (rectangular shape) in which the Y axis direction (non-scanning direction) is the longitudinal direction. The liquid immersion area AR2,

which is filled with the liquid 1, is formed on a part of the substrate P so that the projection area AR1 is included therein. The first supply member 13 of the liquid supply mechanism 10, which is used to form the liquid immersion area AR2 of the projection area AR1, is provided on one side (-X side) in the scanning direction with respect to the projection area AR1, and the second supply member 14 is provided on the other side (+X side).

[0026] The first and second supply members 13, 14 are formed to be substantially circular arc-shaped respectively as viewed in a plan view. The size in the Y axis direction of the supply port 13A, 14A is designed to be larger than at least the size in the Y axis direction of the projection area AR1. The supply ports 13A, 14A, which are formed to be substantially circular arc-shaped as viewed in a plan view, are arranged to interpose the projection area AR1 in relation to the scanning direction (X axis direction). The liquid supply mechanism 10 simultaneously supplies the liquid 1 on the both sides of the projection area AR1 by the aid of the supply ports 13A, 14A of the first and second supply members 13, 14.

[0027] Each of the first and second recovery members 23, 24 of the liquid recovery mechanism 20 has a recovery port 23A, 24A which is formed continuously to be circular arc-shaped so that the recovery port 23A, 24A is directed to the surface of the substrate P. A substantially annular

recovery port is formed by the first and second recovery members 23, 24 which are arranged so that they are opposed to one another. The recovery ports 23A, 24A of the first and second recovery members 23, 24 respectively are arranged to surround the projection area AR1 and the first and second supply members 13, 14 of the liquid supply mechanism 10.

[0028] The liquid 1, which is supplied onto the substrate P from the supply ports 13A, 14A of the first and second supply members 13, 14, is supplied so that the liquid 1 is spread while causing the wetting between the substrate P and the lower end surface of the end portion (optical element 2) of the projection optical system PL. The liquid 1, which outflows to the outside of the first and second supply members 13, 14 with respect to the projection area AR1, is recovered from the recovery ports 23A, 24A of the first and second recovery members 23, 24 which are arranged outside with respect to the projection area AR1 as compared with the first and second supply members 13, 14.

[0029] In this embodiment, when the substrate P is subjected to the scanning exposure, the liquid supply amount per unit time, which is supplied in front of the projection area AR1 in relation to the scanning direction, is set to be larger than the liquid supply amount supplied from the side opposite thereto. For example, when the

exposure process is performed while moving the substrate P in the +X direction, the control unit CONT is operated so that the liquid amount, which is supplied from the -X side (i.e., from the supply port 13A) with respect to the projection area AR1, is larger than the liquid amount which is supplied from the +X side (i.e., from the supply port 14A). On the other hand, when the exposure process is performed while moving the substrate P in the -X direction, the control unit CONT is operated so that the liquid amount, which is supplied from the +X side with respect to the projection area AR1, is larger than the liquid amount which is supplied from the -X side. The liquid recovery amount per unit time, which is recovered in front of the projection area AR1 in relation to the scanning direction, is set to be smaller than the liquid recovery amount on the side opposite thereto. For example, when the substrate P is moved in the +X direction, the recovery amount, which is recovered from the +X side (i.e., from the recovery port 24A) with respect to the projection area AR1, is larger than the recovery amount which is recovered from the -X side (i.e., from the recovery port 23A).

[0030] Fig. 3 shows a plan view illustrating the substrate table PT as viewed from an upper position. Fig. 4 shows a plan view illustrating the substrate table PT which holds the substrate P as viewed from an upper position. With reference to Figs. 3 and 4, movement

mirrors 55 are arranged at two edge portions of the substrate table PT which is rectangular as viewed in a plan view, the two edge portions being perpendicular to one another. A recess 31 is formed at a substantially central portion of the substrate table PT. The substrate holder PH, which constructs a part of the substrate table PT, is arranged in the recess 31. The substrate P is held by the substrate holder PH. The plate member 30, which has the flat surface 30A having approximately the same height as that of (being flush with) the surface of the substrate P, is provided around the substrate P. The plate member 30 is an annular member, which is arranged to surround the substrate holder PH (substrate P). The plate member 30 is formed of a material having the liquid repellence such as polytetrafluoroethylene (Teflon (trade name)). The liquid immersion area AR2 can be satisfactorily formed on the image plane side of the projection optical system PL even when the edge area E of the substrate P is subjected to the liquid immersion exposure, because the plate member 30, which has the flat surface 30A substantially flush with the surface of the substrate P, is provided around the substrate P.

[0031] The second plate member 32 is provided outside the plate member 30 in relation to the substrate holder PH in the upper surface of the substrate table PT. The second plate member 32 has the flat surface 32A which has

substantially the same height as that of (is flush with) the surface of the substrate P and the flat surface 30A of the plate member 30. The second plate member 32 is provided to cover the substantially entire region of the upper surface of the substrate table PT except for the substrate holder PH (substrate P) and the plate member 30. The second plate member 32 is also formed of a material having the liquid repellence including, for example, polytetrafluoroethylene.

[0032] A plurality of openings 32K, 32L, 32N are formed at predetermined positions of the second plate member 32. A reference member 300 is arranged in the opening 32K. A reference mark PFM to be detected by a substrate alignment system 350 and a reference mark MFM to be detected by a mask alignment system 360 are provided in a predetermined positional relationship on the reference member 300. The reference member 300 has an upper surface 301A which is a substantially flat surface. The upper surface 301A may be used as a reference plane for the focus/leveling-detecting system as well. Further, the upper surface 301A of the reference member 300 is provided to have approximately the same height as those of (be flush with) the surface of the substrate P, the surface (flat surface) 30A of the plate member 30, and the surface (flat surface) 32A of the second plate member 32. The reference member 300 is formed to be rectangular as viewed in a plan view. A gap K is formed

between the second plate member 32 and the reference member 300 arranged in the opening 32K. In this embodiment, the gap K is, for example, about 0.3 mm.

[0033] An uneven illuminance sensor 400 as an optical sensor is arranged in the opening 32L, as disclosed, for example, in Japanese Patent Application Laid-open No. 57-117238. An upper surface 401A of the uneven illuminance sensor 400 is a substantially flat surface, which is provided to have approximately the same height as those of (be flush with) the surface of the substrate P, the surface 30A of the plate member 30, and the surface 32A of the second plate member 32. A pinhole 470, through which the light can pass, is provided for the upper surface 401A of the uneven illuminance sensor 400. Portions of the upper surface 401A except for the pinhole 470 are covered with a light-shielding material such as chromium. The uneven illuminance sensor 400 (upper plate 401) is formed to be rectangular as viewed in a plan view. A gap L is formed between the second plate member 32 and the uneven illuminance sensor 400 (upper plate 401) arranged in the opening 32L. In this embodiment, the gap L is, for example, about 0.3 mm.

[0034] A spatial image-measuring sensor 500 as an optical sensor is provided in the opening 32N, as disclosed, for example, in Japanese Patent Application Laid-open No. 2002-14005. An upper surface 501A of an

upper plate 501 of the spatial image-measuring sensor 500 is a substantially flat surface, which may be used as a reference plane for the focus/leveling-detecting system as well. The upper surface 501A is provided to have approximately the same height as those of (be flush with) the surface of the substrate P, the surface 30A of the plate member 30, and the surface 32A of the second plate member 32. A slit 570, through which the light can pass, is provided for the upper surface 501A of the spatial image-measuring sensor 500. Portions of the upper surface 501A except for the slit 570 are covered with a light-shielding material such as chromium. The spatial image-measuring sensor 500 (upper plate 501) is formed to be rectangular as viewed in a plan view. A gap N is formed between the spatial image-measuring sensor 500 (upper plate 501) and the opening 32N. In this embodiment, the gap N is in approximately the same degree as the production tolerance or margin for the outer shape of the substrate P, for example, about 0.3 mm. As described above, the substrate table PT, which holds the substrate P, has the upper surface which is substantially flush over the entire surface.

[0035] Although not shown, the substrate table PT is also provided with a radiation amount sensor (illuminance sensor) which is arranged in an opening formed for the second plate member 32, as disclosed, for example, in

Japanese Patent Application Laid-open No. 11-16816.

[0036] The flat surface 30A of the plate member 30, which is formed to have the annular shape, has the width which is formed to be larger than at least the projection area AR1 (see Fig. 4). Therefore, when the edge area E of the substrate P is subjected to the exposure, the exposure light beam EL is not radiated onto the second plate member 32. Accordingly, it is possible to suppress the deterioration of the liquid repellence of the second plate member 32. The frequency of the exchange of the second plate member 32 can be made smaller than the frequency of the exchange of the plate member 30. Further, it is preferable that the width of the flat surface 30A is formed to be larger than the liquid immersion area AR2 which is formed on the image plane side of the projection optical system PL. Accordingly, when the edge area E of the substrate P is subjected to the liquid immersion exposure, then the liquid immersion area AR2 is arranged on the flat surface 30A of the plate member 30, and the liquid immersion area AR2 is not arranged on the second plate member 32. Therefore, it is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1 of the liquid immersion area AR2 inflows into the gap G as the interstice between the plate member 30 and the second plate member 32.

[0037] As shown in Fig. 3, the substrate holder PH,

which constructs a part of the substrate table PT, includes a substantially annular circumferential wall portion 33, a plurality of support portions 34 which are provided on a base portion 35 disposed inside the circumferential wall portion 33 and which support the substrate P, and a plurality of suction ports 41 which are arranged between the support portions 34 and which are provided in order to attract and hold the substrate P. The support portions 34 and the suction ports 41 are arranged uniformly at the inside of the circumferential wall portion 33. In the figure, the upper end surface of the circumferential wall portion 33 is depicted to have a relatively wide width. However, the upper end surface actually has only a width of about 1 to 2 mm. The base portion 35 is provided with holes 71 which are arranged with lifting members 70 constructed of pin members for moving the substrate P upwardly and downwardly. In this embodiment, the lifting members 70 are provided at three positions respectively. The lifting member 70 is moved upwardly and downwardly by an unillustrated driving unit. The control unit CONT controls the upward/downward movement of the lifting member 70 by the aid of the driving unit.

[0038] A plurality of suction holes 72, which are provided in order to attract and hold the plate member 30 with respect to the substrate table PT, are disposed at positions of the upper surface of the substrate table PT

opposed to the lower surface of the plate member 30. Lifting members 74, which are constructed of pin members for moving the plate member 30 upwardly and downwardly with respect to the substrate table PT, are provided at a plurality of positions (three positions in this arrangement) of the substrate table PT. The lifting member 74 is moved upwardly and downwardly by an unillustrated driving unit. The control unit CONT controls the upward and downward movement of the lifting member 74 by the aid of the driving unit. Further, although not shown, a plurality of suction holes, which are provided in order to attract and holds the second plate member 32 with respect to the substrate table PT, are disposed at positions of the upper surface of the substrate table PT opposed to the lower surface of the second plate member 32. Lifting members, which move the second plate member 32 upwardly and downwardly with respect to the substrate table PT, are provided at a plurality of positions of the substrate table PT.

[0039] The exchange frequency of the second plate member 32 is small as described above. Therefore, the second plate member 32 may be fixed by, for example, the screw fastening rather than being attracted and held with respect to the substrate table PT, and the exchange operation may be performed manually. It is also allowable that the second plate member 32 is not exchangeable.

[0040] As shown in Fig. 4, a predetermined gap A is formed between the plate member 30 and a side surface PB of the substrate P held by the substrate holder PH (substrate table PT).

[0041] Fig. 5 is a magnified sectional view illustrating main parts of the substrate table PT which holds the substrate P. With reference to Fig. 5, the substrate holder PH, which holds the substrate P, is arranged in the recess 31 of the substrate table PT. The substrate table PT is formed so that an upper end surface 34A of the substrate holder PH is higher than the placing surface PTa of the substrate table PT for the plate member 30 and the second plate member 32, when the substrate holder PH is arranged in the recess 31. The circumferential wall portion 33 and the support portions 34 are provided on the substantially disk-shaped base portion 35 which constructs a part of the substrate holder PH. Each of the support portions 34 is trapezoidal as viewed in a sectional view. The back surface PC of the substrate P is held by the upper end surface 34A of the plurality of support portions 34. The upper surface 33A of the circumferential wall portion 33 is a flat surface. The height of the circumferential wall portion 33 is lower than the height of the support portion 34. A gap B is formed between the substrate P and the circumferential wall portion 33. The gap B is smaller than the gap A which is provided between the plate member

30 and the side surface PB of the substrate P. A gap C is formed between the inner side surface 36 of the recess 31 and the side surface 37 of the substrate holder PH opposed to the inner side surface 36. In this arrangement, the diameter of the substrate holder PH is formed to be smaller than the diameter of the substrate P. The gap A is smaller than the gap C. In this embodiment, any cutout (for example, orientation flat or notch), which is to be used for the positioning, is not formed for the substrate P. The substrate P is substantially circular. The gap A is 0.1 mm to 1.0 mm, which is about 0.3 mm in this embodiment over the entire circumference of the substrate. Therefore, it is possible to avoid the inflow of the liquid. When any cutout is formed for the substrate P, the plate member 30 and the circumferential wall portion 33 may be allowed to shapes adapted to the cutout, for example, such that projections are provided for the plate member 30 and the circumferential wall portion 33 depending on the cutout. Accordingly, the gap A can be also secured between the substrate P and the plate member 30 at the cutout of the substrate P.

[0042] An inner stepped portion 30D is formed at an inner portion of the plate member 30. A support surface 30S, which is opposed to the lower surface PB of the edge portion of the substrate P, is formed by the inner stepped portion 30D. The plate member 30 is capable of supporting

the lower surface PB of the edge portion of the substrate P by the support surface 30S. In this arrangement, as shown in Fig. 5, a gap D is formed between the lower surface of the edge portion of the substrate P held by the substrate holder PH and the support surface 30S of the plate member 30 held by the placing surface PTa of the substrate table PT. Accordingly, it is possible to avoid the occurrence of the inconvenience which would be otherwise caused such that the plate member 30 (support surface 30S) abuts against the lower surface of the edge portion of the substrate P, and the edge portion of the substrate P is warped upwardly.

[0043] An inner stepped portion 32D is formed at an inner portion of the second plate member 32. An outer stepped portion 32F is formed at an outer portion of the plate member 30 so that the outer stepped portion 32F is adapted to the shape of the inner stepped portion 32D of the second plate member 32. Accordingly, a state is given, in which a part of the plate member 30 is placed on a part of the second plate member 32. A predetermined gap G is formed between the outer side surface of the plate member 30 and the inner side surface of the second plate member 32. In this embodiment, the gap G is, for example, about 0.3 mm. The gap G is interposed by the second plate member 32 and the plate member 30 made of polytetrafluoroethylene having the liquid-repellent surface. Therefore, even when

the liquid immersion area is formed at the boundary between the plate member 30 and the second plate member 32, it is possible to avoid the inflow of the liquid into the gap G.

[0044] The surface PA as the exposure surface of the substrate P is coated with a photoresist (photosensitive material) 90. In this embodiment, the photosensitive material 90 is a photosensitive material for the ArF excimer laser (for example, TARF-P6100 produced by TOKYO OHKA KOGYO CO., LTD.). The photosensitive material 90 is liquid-repellent (water-repellent), and the contact angle thereof is about 70° to 80°.

[0045] In this embodiment, the side surface PB of the substrate P is subjected to a liquid-repelling treatment (water-repelling treatment). Specifically, the side surface PB of the substrate P is also coated with the photosensitive material 90 having the liquid repellence. Accordingly, it is possible to avoid the inflow of the liquid from the gap A between the side surface of the substrate P and the plate member 30 having the liquid-repellent surface. Further, the back surface PC of the substrate P is also subjected to a liquid-repelling treatment by coating the back surface PC with the photosensitive material 90.

[0046] In this embodiment, the placing surface PTa and the inner side surface 36 of the substrate table PT have the liquid repellence. Further, a part of the surface of

the substrate holder PH is also subjected to the liquid-repelling treatment to have the liquid repellence. In this embodiment, the side surface 37 and the upper surface 33A of the circumferential wall portion 33 of the substrate holder PH have the liquid repellence. When the liquid-repelling treatment is performed for the substrate table PT and the substrate holder PH, for example, a liquid-repellent material including, for example, fluorine-based resin materials and acrylic resin materials is coated, or a thin film composed of the liquid-repellent material as described above is stuck. A material, which is insoluble in the liquid 1, is used as the liquid-repellent material in order to provide the liquid repellence. The entire substrate table PT and/or the entire substrate holder PH may be formed of a material having the liquid repellence (for example, fluorine-based resin).

[0047] A first space 38, which is surrounded by the circumferential wall portion 33 of the substrate holder PH, is allowed to have the negative pressure by a sucking unit 40. The sucking unit 40 includes a plurality of suction ports 41 which are provided on the upper surface of the base portion 35 of the substrate holder PH, a vacuum section 42 which includes a vacuum pump provided externally with respect to the substrate table PT, and a flow passage 43 which is formed in the base portion 35 and which connects the plurality of suction ports 41 and the vacuum

section 42 respectively. The suction ports 41 are provided at a plurality of predetermined positions of the upper surface of the base portion 35 except for the support portions 34 respectively. The sucking unit 40 sucks the gas (air) contained in the first space 38 formed among the circumferential wall portion 33, the base portion 35, and the substrate P supported by the support portions 34 so that the first space 38 is allowed to have the negative pressure. Accordingly, the substrate P is attracted and held by the support portions 34. The gap B, which is formed between the back surface PC of the substrate P and the upper surface 33A of the circumferential wall portion 33, is minute. Therefore, the negative pressure of the first space 38 is maintained.

[0048] The liquid 1, which flows into a second space 39 between the inner side surface 36 of the recess 31 and the side surface 37 of the substrate holder PH, is recovered by a recovery section 60. In this embodiment, the recovery section 60 has a tank 61 which is capable of accommodating the liquid 1, and a flow passage 62 which is provided in the substrate table PT and which connects the space 39 and the tank 61. The liquid-repelling treatment is also performed to the inner wall surface of the flow passage 62.

[0049] The substrate table PT is formed with a flow passage 45 which connects the second space 39 disposed between the inner side surface 36 of the recess 31 and the

side surface 37 of the substrate holder PH and the space (atmospheric air space) disposed outside the substrate table PT. The gas (air) is capable of flowing via the flow passage 45 between the second space 39 and the outside of the substrate table PT. The second space 39 is approximately set to have the atmospheric pressure.

[0050] As shown in Fig. 6, the substrate holder PH, the plate member 30, and the second plate member 32 are provided detachably with respect to the substrate table PT. The contact surface 57, of the substrate table PT, which makes contact with the substrate holder PH is subjected to the liquid-repelling treatment to have the liquid repellence. Further, the back surface 58 of the substrate holder PH, which is the contact surface with respect to the substrate table PT, is also subjected to the liquid-repelling treatment to have the liquid repellence. The liquid-repelling treatment for the contact surface 57 and the back surface 58 can be performed, for example, by coating the liquid-repellent material such as fluorine-based resin materials and acrylic resin materials as described above.

[0051] Next, an explanation will be made with reference to schematic views shown in Figs. 7 and 8 about the method for exposing the substrate P by using the exposure apparatus EX constructed as described above.

As shown in Fig. 7(a), the plate member 30 is

attracted and held by the placing surface PTa of the substrate table PT, and the second plate member 32 is also attracted and held by the placing surface PTa of the substrate table PT. The substrate P as the exposure process objective is loaded to the substrate table PT by a transport arm (transport unit) 80. In this situation, the lifting members 70 are moved upwardly. The transport arm 80 delivers the substrate P to the lifting members 70 which are moved upwardly. The lifting members 74 are not moved upwardly. The lifting members 70 are moved downwardly while holding the substrate P delivered from the transport arm 80. Accordingly, as shown in Fig. 7(b), the substrate P is arranged inside the plate member 30, and the substrate P is held by the substrate table PT (substrate holder PH). As shown in Fig. 7(c), the control unit CONT performs the supply and the recovery of the liquid 1 by the liquid supply mechanism 10 and the liquid recovery mechanism 20 to form the liquid immersion area AR2 of the liquid 1 between the projection optical system PL and the substrate P held by the substrate table PT. The control unit CONT radiates the exposure light beam EL onto the substrate P via the projection optical system PL and the liquid 1 to perform the liquid immersion exposure while moving the substrate stage PST which supports the substrate P.

[0052] When the edge area E of the substrate P is subjected to the exposure, the exposure light beam EL is

radiated onto the flat surface 30A of the plate member 30. As a result of the irradiation with the exposure light beam EL, there is such a possibility that the liquid repellence of the flat surface 30A may be deteriorated. If the liquid repellence of the flat surface 30A is deteriorated, for example, the following inconvenience arises. That is, the liquid 1 of the liquid immersion area AR2 arranged on the flat surface 30A tends to remain to cause the variation of the environment in which the substrate P is placed. Accordingly, the control unit CONT exchanges the plate member 30 in which the liquid repellence is deteriorated, with a new plate member 30 (having sufficient liquid repellence), depending on the deterioration of the liquid repellence of the plate member 30 (flat surface 30A).

[0053] Specifically, the liquid 1, which remains on the substrate P and/or the flat surface 30A, is recovered by using, for example, the liquid recovery mechanism 20 after the completion of the liquid immersion exposure process. After that, as shown in Fig. 7(d), the control unit CONT moves the lifting members 74 upwardly after releasing the plate member 30 from the state of being attracted and held. In this situation, the substrate P is also released from the state of being attracted and held by the substrate holder PH. The lifting members 74 are moved upwardly in a state in which the lower surface of the plate member 30 is supported. In this situation, the lifting members 70 are

not moved upwardly. Accordingly, the plate member 30 is separated or away from the substrate table PT. In this situation, the support surface 30S of the plate member 30 supports the lower surface PB of the edge portion of the substrate P. Therefore, the substrate P is moved upwardly together with the plate member 30, and the substrate P is separated from the substrate table PT. As described above, the lifting members 74, which construct the attachment/detachment mechanism for attaching/detaching the plate member 30 with respect to the substrate table PT, are capable of detaching the plate member 30 from the substrate table PT together with the substrate P. The transport arm 80 enters the space between the substrate table PT and the plate member 30 having been moved upwardly by the lifting members 74. The transport arm 80 supports the lower surface of the plate member 30. The transport arm 80 unloads the plate member 30 which holds the substrate P, out of the substrate table PT (substrate stage PST).

[0054] The unloaded plate member 30 is exchanged with a new plate member 30. As shown in Fig. 8(a), the control unit CONT loads a new plate member 30 which holds a substrate P as the exposure process objective, to the substrate table PT (substrate stage PST) by using the transport arm 80. In this situation, the lifting members 74 are moved upwardly, and the transport arm 80 delivers the plate member 30 which holds the substrate P, to the

lifting members 74 which are moved upwardly. The lifting members 70 are not moved upwardly. The lifting members 74 are moved downwardly while holding the plate member 30 which has been delivered from the transport arm 80. Accordingly, as shown in Fig. 8(b), the plate member 30, which holds the substrate P, is arranged inside the second plate member 32, and the plate member 30 is held by the substrate table PT (substrate holder PH). As shown in Fig. 8(c), the control unit CONT performs the supply and the recovery of the liquid 1 by the liquid supply mechanism 10 and the liquid recovery mechanism 20 to form the liquid immersion area AR2 of the liquid 1 between the projection optical system PL and the substrate P held by the substrate table PT. The control unit CONT radiates the exposure light beam EL onto the substrate P via the projection optical system PL and the liquid 1 to perform the liquid immersion exposure while moving the substrate stage PST which holds the substrate P.

[0055] When the liquid repellence of the plate member 30 is not deteriorated yet, the liquid 1, which remains, for example, on the substrate P, is recovered by using, for example, the liquid recovery mechanism 20 after the completion of the liquid immersion exposure. After that, the control unit CONT releases the substrate P from the state of being attracted and held. After that, as shown in Fig. 8(d), the lifting members 70 are moved upwardly. In

this situation, the plate member 30 is attracted and held by the substrate table PT. The lifting members 70 are moved upwardly in a state in which the lower surface of the substrate P is supported. In this situation, the lifting members 74 are not moved upwardly. Accordingly, the substrate P is separated from the substrate table PT. The transport arm 80 enters the space between the substrate table PT and the substrate P having been moved upwardly by the lifting members 70, and the lower surface of the substrate P is supported thereby. The transport arm 80 unloads the substrate P from the substrate table PT (substrate stage PST).

[0056] As for the transport arm 80, it is also allowable that a transport arm for transporting the plate member 30 and a transport arm for transporting the substrate P are provided separately. However, as shown in Fig. 9, the following arrangement is available. That is, a support surface 80A of a transport arm 80 is formed to be large so that the transport arm 80 can make contact with both of the substrate P and the plate member 30. Accordingly, it is possible to support both of the substrate P and the plate member 30. Therefore, both of the substrate P and the plate member 30 can be transported with one transport arm 80.

[0057] As explained above, the liquid-repellent plate member 30, which is provided for the substrate table PT, is

provided exchangeably. Therefore, when the liquid repellence of the plate member 30 is deteriorated, the liquid repellence on the substrate table PT can be maintained by merely exchange the plate member 30 with the new plate member 30. Therefore, it is possible to suppress the remaining of the liquid 1 on the substrate table PT. Even when the liquid 1 remains, the liquid 1 can be smoothly recovered by using, for example, the liquid recovery mechanism 20. Therefore, the deterioration of the exposure accuracy, which would be caused by the remaining liquid 1, can be avoided. It is possible to produce the device which can exhibit the desired performance.

[0058] The plate member 30, which has the flat portion 30A around the substrate P, is loaded and unloaded together with the substrate P with respect to the substrate table PT. Accordingly, the plate member 30 can be easily exchanged together with the substrate P with respect to the substrate table PT. Further, the plate member 30 has the flat surface 30A around the substrate P. Therefore, when the plate member 30 is loaded to the substrate table PT together with the substrate P and the liquid immersion exposure is performed for the edge area E of the substrate P, even if a part of the liquid immersion area AR2 of the liquid 1 protrudes to the outside of the substrate P, then the shape of the liquid immersion area AR2 is maintained by the flat surface 30A. The liquid immersion exposure can be

performed in such a state that the liquid 1 is satisfactorily retained on the image plane side of the projection optical system PL, without causing, for example, the outflow of the liquid 1.

[0059] The inner stepped portion 30D is provided at the inner portion of the plate member 30 to form the support surface 30S so that the lower surface PB of the edge portion of the substrate P can be supported. Therefore, the substrate P can be moved together with the plate member 30 by merely effecting the movement while holding the plate member 30. The corner or turning portion is formed as viewed in a sectional view between the plate member 30 and the substrate P by the inner stepped portion 30D. Therefore, even if the liquid 1 enters the gap A between the plate member 30 and the substrate P, the corner functions as a seal portion. It is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1 inflows into the side of the back surface PB of the substrate P and the substrate stage PST (substrate table PT). Further, the side surface PB of the substrate P is also subjected to the liquid-repelling treatment. Therefore, it is possible to satisfactorily avoid the inflow of the liquid 1 from the gap A between the side surface PB of the substrate P and the plate member 30.

[0060] The inconvenience, which would be otherwise caused such that the liquid 1 inflows into the first space

38 via the gap B, can be avoided by providing the liquid repellence for the back surface PC of the substrate P and the upper surface 33A of the circumferential wall portion 33 opposed to the back surface PC. Therefore, it is possible to avoid the occurrence of the inconvenience which would be otherwise caused such that the liquid 1 flows into the suction ports 41. The exposure process can be performed in such a state that the substrate P is satisfactorily attracted and held.

[0061] In the embodiment of the present invention, the liquid-repelling treatment is performed to the back surface 58 of the substrate holder PH which is detachable with respect to the substrate table PT, and the contact surface 57, of the substrate table PT, which makes contact with the substrate holder PH. Accordingly, even when the liquid 1 flows into the second space 39, it is possible to suppress the inflow of the liquid 1 into the space between the back surface 58 of the substrate holder PH and the contact surface 57 of the Z stage 52. Therefore, it is possible to avoid, for example, the occurrence of any rust on the back surface 58 of the substrate holder PH and the contact surface 57 of the substrate table PT. If the liquid 1 inflows into the space between the back surface 58 of the substrate holder PH and the contact surface 57 of the substrate table PT, a situation arises such that the substrate holder PH and the Z stage 52 are adhered to one

another and they are hardly separated from each other. However, the separation can be effected with ease by providing the liquid repellence.

[0062] As for the attachment/detachment mechanism for attaching and detaching the plate member 30 with respect to the substrate table PT, the lifting members 74 are provided to serve as the lifting unit, and the suction holes 72 are provided to serve as the attracting/holding unit for attracting and holding the plate member 30. Therefore, it is possible to smoothly perform the operation for exchanging the plate member 30. The new plate member 30 after the exchange can be satisfactorily held on the substrate table PT.

[0063] The inner stepped portion 32D is formed at the inner portion of the second plate member 32, and the outer stepped portion 30F is formed at the outer portion of the plate member 30. Accordingly, the corner is also formed as viewed in a sectional view at the gap between the plate member 30 and the second plate member 32. Therefore, even if the liquid 1 inflows from the gap G, the corner functions as a seal portion. It is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1 arrives at the inside of the substrate table PT.

[0064] The outer stepped portion 30F of the plate member 30 can be supported by the inner stepped portion 32D of the second plate member 32. Therefore, it is not necessarily

indispensable that the plate member 30 is held by the substrate table PT, because the plate member 30 is supported by the second plate member 32 when the second plate member 32 is attracted and held by the substrate table PT. Therefore, as schematically shown in Fig. 10, a space (dent) 130 can be formed in an area of the substrate table PT opposed to the plate member 30. It is possible to realize a light weight of the substrate table PT (substrate stage PST).

[0065] In this arrangement, the substrate P is transported by the transport arm 80 in the state in which the substrate P is held by the plate member 30. Therefore, a relatively wide area of the substrate P is supported by the plate member 30. Therefore, for example, even when the substrate P is large-sized, the flexure (warpage) of the substrate P can be suppressed by transporting the substrate P in the state of being held by the plate member 30.

[0066] The timing of the exchange of the plate member 30, 32 includes, for example, every interval of a predetermined number of pieces of processed substrates and/or every interval of a predetermined period of time. The plate members 30, 32 can be exchanged at predetermined intervals which are previously prescribed. Alternatively, the relationship between the radiation amount (radiation time, illuminance) of the exposure light beam EL and the level of the liquid repellence of the plate member 30, 32

is previously determined by an experiment or simulation. The timing of the exchange of the plate member 30 may be set on the basis of the determined result.

[0067] In the embodiment of the present invention, the plate member 30, 32 is formed of, for example, polytetrafluoroethylene which is the liquid-repellent material. However, it is a matter of course that the plate member 30, 32 may be formed of any other material having the liquid repellence. Alternatively, for example, the plate member 30, 32 may be formed of a predetermined metal, and the surface of the plate member 30 made of metal may be coated with the liquid-repellent material (such as polytetrafluoroethylene) having the liquid repellence. As for the coating area of the liquid-repellent material, the entire surface of the plate member 30, 32 may be subjected to the coating, or only a part of the area including, for example, the flat surface 30A, which requires the liquid repellence, may be subjected to the coating.

[0068] It is a matter of course that the plate member 30 and the second plate member 32 may be formed of separate materials, and the plate member 30 and the second plate member 32 may be subjected to the coating by using liquid-repellent materials which are distinct from each other. It is not necessarily indispensable that all of the surfaces of the plate member 30 and the second plate member 32 have the liquid repellence at a uniform level. It is also

allowable that a portion having the strong liquid repellence may be partially provided. It is not necessarily indispensable that all of the surfaces of the plate member 30 and the second plate member 32 have the same or equivalent durability against the deterioration of the liquid repellence. It is also allowable that the durability against the deterioration of a portion which undergoes a large radiation amount of the exposure light beam may be strengthened as compared with other portions. For example, it is preferable that the surface of the plate member 30 has the durability against the deterioration which is stronger than that of the surface of the second plate member 32.

[0069] The embodiment of the present invention has been explained such that the plate member 30 is unloaded together with the substrate P when the plate member 30 is exchanged. It is a matter of course that only the plate member 30 may be loaded and unloaded with respect to the substrate table PT.

[0070] The plate member 30 can be exchanged by using the lifting members 74 and the transport arm 80. However, it is not necessarily indispensable to provide the lifting members 74 and the transport arm 80 which is capable of transporting the plate member 30. The plate member 30 may be exchanged manually by an operator. In the embodiment described above, the plate member 30 and the second plate

member 32 are provided integrally respectively. However, it is also allowable that the plate member 30 and the second plate member 32 may be divided respectively so that they can be partially exchanged. Accordingly, it is also possible to frequently exchange only a portion at which the deterioration of the liquid repellence is seriously deteriorated.

[0071] In the embodiment of the present invention, the substrate holder PH and the substrate table PT are detachable. However, the substrate holder PH may be provided integrally with the substrate table PT.

[0072] In the embodiment of the present invention, the entire surfaces of the surface PA, the side surface PB, and the back surface PC of the substrate P are coated with the photosensitive material 90 in order to perform the liquid-repelling treatment. However, another arrangement is also available, in which the liquid-repelling treatment is performed to only the area for forming the gap A, i.e., the side surface PB of the substrate P and the area for forming the gap B, i.e., the area of the back surface PC of the substrate P opposed to the upper surface 33A of the circumferential wall portion 33. Further, when the gap A is sufficiently small, and the material, which is coated to effect the liquid-repelling treatment, has the sufficiently large liquid repellence (contact angle), then the possibility of the inflow of the liquid 1 into the second

space 39 via the gap A is further lowered. Therefore, an arrangement is also available, in which the liquid-repelling treatment is not performed to the back surface PC of the substrate P for forming the gap B, and the liquid-repelling treatment is performed to only the side surface PB of the substrate P.

[0073] In the embodiment of the present invention, the height of the circumferential wall portion 33 is lower than the height of the support portion 34, and the gap B is formed between the back surface PC of the substrate P and the upper surface 33A of the circumferential wall portion 33. However, the back surface PC of the substrate P and the upper surface 33A of the circumferential wall portion 33 may make contact with each other.

[0074] In the embodiment of the present invention, the photosensitive material 90 having the liquid repellence is coated as the liquid-repelling treatment for the side surface PB and the back surface PC of the substrate P. However, the side surface PB and the back surface PC may be coated with a predetermined material having the liquid repellence (water repellence) other than the photosensitive material 90. For example, a protective layer called "top coat layer" (film to protect the photosensitive material 90 from the liquid) is coated or formed as the upper layer of the photosensitive material 90 coated to the surface PA as the exposure surface of the substrate P in some cases. The

material for forming the top coat layer (for example, fluorine-based resin material) has the liquid repellence (water repellence) with a contact angle of, for example, about 110°. Therefore, the side surface PB and the back surface PC of the substrate P may be coated with the material for forming the top coat layer. Of course, any material having the liquid repellence other than the photosensitive material 90 and the material for forming the top coat layer may be coated.

[0075] In the embodiment of the present invention, for example, the fluorine-based resin material or the acrylic resin material is coated as the liquid-repelling treatment for the substrate table PT and the substrate holder PH. However, the substrate table PT and the substrate holder PH may be coated with the photosensitive material or the material for forming the top coat layer. On the other hand, the side surface PB and the back surface PC of the substrate P may be coated with the material used for the liquid-repelling treatment for the substrate stage PST and the substrate holder PH.

[0076] The top coat layer is provided in order to prevent the liquid 1 of the liquid immersion area AR2 from the infiltration into the photosensitive material 90 in many cases. For example, even when the adhesion trace (so-called "water mark") of the liquid 1 is formed on the top coat layer, a predetermined process treatment such as the

development process can be performed after removing the water mark together with the top coat layer, by removing the top coat layer after the liquid immersion exposure. In this procedure, when the top coat layer is formed of, for example, a fluorine-based resin material, the top coat layer can be removed by using a fluorine-based solvent. Accordingly, it is unnecessary to provide any unit for removing the water mark (for example, a substrate-washing unit for removing the water mark). The predetermined process treatment can be satisfactorily performed after removing the water mark by a simple configuration in which the top coat layer is removed with the solvent.

[0077] Next, another embodiment of the present invention will be explained. In the following description, parts or components, which are the same as or equivalent to those of the embodiment described above, are designated by the same reference numerals, any explanation of which will be simplified or omitted.

Fig. 11 shows a substrate holder PH which is attached/detached with respect to the substrate table PT (substrate stage PST). Fig. 11(a) shows a side sectional view, and Fig. 11(b) shows a plan view as viewed from an upper position, illustrating the substrate table PT after the substrate holder PH is detached.

As shown in Fig. 11, the substrate table PT includes, on an upper surface thereof (holding surface for the

substrate holder PH), a recess 157 to which the substrate holder PH is capable of being fitted, and a plurality of vacuum suction holes 158 which are provided in the recess 157 and which attract and hold the substrate holder PH arranged in the recess 157. When the substrate holder PH is fitted to the recess 157, the substrate table PT and the substrate holder PH are positioned. The vacuum suction holes 158 construct a part of the chuck mechanism for holding the substrate holder PH arranged in the recess 157. The vacuum suction holes 158 are connected to an unillustrated vacuum unit. The driving of the vacuum unit is controlled by the control unit CONT. The control unit CONT controls the vacuum unit to effect the attraction and the holding as well as the release from the holding of the substrate table PT with respect to the substrate holder PH by the aid of the vacuum suction holes 158. When the substrate table PT is released from the holding, then the substrate holder PH and the substrate table PT can be separated from each other, and the substrate holder PH can be exchanged.

[0078] In this embodiment, the explanation has been made such that the substrate table PT holds the substrate holder PH by the vacuum attraction. However, the substrate holder PH may be subjected to the holding and the release from the holding by another chuck mechanism including, for example, an electromagnetic chuck mechanism. In this embodiment,

the explanation has been made such that the substrate table PT and the substrate holder PH are positioned by using the recess 157. However, for example, the following arrangement is also available. That is, the positional relationship between the substrate holder PH and the substrate table PT is optically detected, and the substrate holder PH is positioned at a predetermined position with respect to the substrate table PT on the basis of the result of the detection.

[0079] The substrate holder PH has a recess 150 in which the substrate P is to be arranged, and a flat surface 30A which is substantially flush with the surface of the substrate P arranged in the recess 150. The flat surface 30A is provided annularly around the substrate P. A side wall portion 151, which is higher than the flat surface 30A, is formed around the flat surface 30A. The side wall portion 151 is formed continuously and annularly around the flat surface 30A. The liquid 1 can be retained inside the side wall portion 151 (on the substrate P and on the flat surface 30A).

[0080] The substrate holder PH is formed of a material having the liquid repellence including, for example, polytetrafluoroethylene. The substrate holder PH may be formed of, for example, a predetermined metal. At least the flat surface 30A of the substrate holder PH made of metal may be coated with a liquid-repellent material (for

example, polytetrafluoroethylene) having the liquid repellence. Of course, the entire region of the surface of the substrate holder PH made of metal may be coated with a liquid-repellent material.

[0081] The transport arm 80 is capable of transporting the substrate holder PH detached from the substrate table PT. For example, the transport arm 80 can be operated as follows. That is, the substrate holder PH, which holds the substrate P after being subjected to the exposure process, is unloaded from the substrate table PT (substrate stage PST). The substrate holder PH is exchanged with another substrate holder PH. After that, the another substrate holder PH is loaded to (loaded on) the substrate table PT. When the substrate holder PH is loaded to the substrate table PT, then the transport arm 80 can load only the substrate holder PH, or the transport arm 80 can load the substrate holder PH which holds the substrate P before being subjected to the exposure process.

[0082] Fig. 12 shows the substrate holder PH. Fig. 12(a) shows a side sectional view, and Fig. 12(b) shows a plan view as viewed from an upper position.

With reference to Fig. 12, the substrate holder PH includes a side wall portion 151 which is capable of retaining the liquid 1 as described above, a plurality of projections 161 which are formed on a bottom surface portion PHT of the recess 150, and vacuum suction holes 162

which are formed on upper end surfaces of the projections 161 respectively. The upper end surfaces of the projections 161 are flat surfaces. The substrate holder PH supports the substrate P on the upper end surfaces of the plurality of recesses 161. Further, the substrate holder PH attracts and holds the substrate P by the aid of the vacuum suction holes 162. In this embodiment, the projections 161 are provided at a plurality of predetermined positions of the bottom surface portion PHT of the recess 150 of the substrate holder PH respectively so that the supported substrate P is not warped. When the substrate P is supported by the projections 161, a spacing portion 164 is formed between the substrate P and the bottom surface portion PHT of the substrate holder PH. In this embodiment, the shape of the substrate holder PH, which is viewed in a plan view, is substantially circular. However, the shape may be rectangular.

[0083] When the substrate table PT and the substrate holder PH are connected to each other, the vacuum suction holes 162 of the substrate holder PH are connected to the flow passages 159 (see, for example, Fig. 11(b)) provided on the upper surface of the substrate table PT, via flow passages 162A formed in the substrate holder PH. The flow passages 159 are connected to the vacuum unit. When the control unit CONT drives the vacuum unit, the substrate P, which is supported by the projections 161, is attracted and

held via the flow passages 159 of the substrate table PT, the flow passages 162A of the substrate holder PH, and the vacuum suction holes 162. Valves 162B, which are constructed of, for example, solenoid-operated valves to be driven under the control of the control unit CONT, are provided for the flow passages 162A respectively. The operation for opening/closing the flow passage 162A can be subjected to the remote control. The control unit CONT opens the flow passages 162A by controlling the valves 162B when the vacuum unit is driven, and the control unit CONT closes the flow passages 162A when the vacuum unit is stopped. Therefore, after the attracting operation for the substrate P by the aid of the vacuum suction holes 162, the driving of the vacuum unit is stopped, and the flow passages 162A are closed by the valves 162B. Accordingly, the negative pressure of the flow passages 162A is maintained. Therefore, even when the substrate table PT and the substrate holder PH are separated from each other, the substrate holder PH can maintain the attraction and the holding of the substrate P by allowing the flow passages 162A to have the negative pressure.

[0084] Next, an explanation will be made with reference to a schematic view shown in Fig. 13 about the operation of the exposure apparatus EX constructed as described above.

As shown in Fig. 13(a), the substrate holder PH, which holds the substrate P as the exposure process objective, is

loaded to the substrate table PT together with the substrate P by the transport arm (transport unit) 80. As shown in Fig. 13(b), the substrate holder PH is arranged so that the substrate holder PH is fitted to the recess 157 provided for the substrate table PT. The substrate holder PH is held by the chuck mechanism having the vacuum suction holes 158. The control unit CONT drives the vacuum unit to vacuum-attract and hold the substrate P by the aid of the flow passages 159, the flow passages 162A, and the vacuum suction holes 162 (not shown in Fig. 13). In this situation, the valves 162B open the flow passages 162A. As shown in Fig. 13(c), the control unit CONT supplies and recovers the liquid 1 by the liquid supply mechanism 10 and the liquid recovery mechanism 20 to form the liquid immersion area AR2 of the liquid 1 between the projection optical system PL and the substrate P held on the substrate table PT by the aid of the substrate holder PH. The control unit CONT radiates the exposure light beam EL onto the substrate P via the projection optical system PL and the liquid 1 to perform the liquid immersion exposure while moving the substrate P held on the substrate table PT (substrate stage PST) by the aid of the substrate holder PH. In this situation, the vacuum suction holes 162 are closed by the substrate P which is attracted and held. Therefore, even when the liquid 1 is supplied, the liquid 1 does not inflow into the vacuum suction holes 162. The

liquid 1, which is disposed on the substrate P and on the flat surface 30A, does not outflow to the outside of the substrate holder PH owing to the side wall portion 151 of the substrate holder PH as well.

[0085] After the completion of the liquid immersion exposure for the substrate P, the control unit CONT recovers the liquid 1 remaining on the substrate P and on the flat surface 30A by using, for example, the liquid recovery mechanism 20. Subsequently, the control unit CONT releases the holding of the substrate holder PH having been effected by the chuck mechanism including the vacuum suction holes 158. Further, the flow passages 162A are closed by using the valves 162B. As shown in Fig. 13(d), the control unit CONT unloads the substrate holder PH in a state of holding the substrate P for which the exposure process has been completed, from the substrate table PT together with the substrate P by the transport arm 80. When the substrate holder PH is separated from the substrate table PT, the flow passages 162A, which are connected to the vacuum suction holes 162 that attract and hold the substrate P, are closed by the valves 162B to maintain the negative pressure state as explained with reference to Fig. 12. Therefore, the attraction and the holding for the substrate P, which are effected by the upper end surfaces of the projections 161, are maintained. When the substrate P is transported together with the

substrate holder PH, even if the liquid 1 remains on the substrate P and on the flat surface 30A, then the remaining liquid 1 does not outflow via the flow passages 162A. The remaining liquid 1 is retained inside the side wall portion 151. Therefore, the remaining liquid 1 does not outflow to the outside of the substrate holder PH, and the remaining liquid 1 is not scattered into the transport passage as well.

[0086] The unloaded substrate holder PH is exchanged with a new substrate holder PH. The control unit CONT loads the new substrate holder PH which holds the substrate P as the exposure process objective, to the substrate table PT (substrate stage PST) by using the transport arm 80.

[0087] The foregoing embodiments have been explained such that the member (plate member 30, second plate member 32, substrate holder PH), which has the flat surface 30A around the substrate P, is exchanged depending on the deterioration of the liquid repellence thereof. However, it is desirable that any member other than the plate member 30 (substrate holder PH) provided on the substrate table PT has its liquid-repellent surface. It is appropriate that such a member is exchangeable depending on the deterioration of the liquid repellence thereof. Specifically, the constitutive members of the reference member 300 and the constitutive members of the optical sensors 400, 500, which are used while forming the liquid

immersion area on the surface, may also be exchangeable.

[0088] Fig. 14 shows a sectional view illustrating the reference member 300 provided on the substrate table PT. With reference to Fig. 14, the reference member 300 includes an optical member 301 which is formed of glass (CLEARCERAM), and the reference marks MFM, PFM which are formed on the upper surface 301A of the optical member 301. The reference member 300 is attached onto the substrate table PT. As described above, the reference member 300 is arranged in the opening 32K provided for the second plate member 32, and the upper surface 301A is exposed. The reference member 300 (optical member 301) is detachable with respect to the substrate table PT, and the reference member 300 (optical member 301) is exchangeable. Quartz may be used as the optical member 301.

[0089] A gap K, which is, for example, about 0.3 mm, is provided between the reference member 300 and the opening 32K. The upper surface 301A of the optical member 301 (reference member 300) is a substantially flat surface which is provided to have approximately the same height as those of (be flush with) the surface of the substrate P, the surface 30A of the plate member 30, and the surface 32A of the second plate member 32.

[0090] Portions of the second plate member 32, which are disposed in the vicinity of the reference member 300, are thin-walled. An end of a thin-walled portion 32S, of the

thin-walled portion, which is disposed on the side of the reference member 300, is bent downwardly to form a bent portion 32T. A wall section 310, which protrudes upwardly, is formed on the substrate table PT. The wall section 310 is provided outside the bent portion 32T in relation to the reference member 300. The wall section 310 is formed continuously to surround the reference member 300 (bent portion 32T). The outer side surface 32Ta of the bent portion 32T is opposed to the inner side surface 310A of the wall section 310. The inner side surface 32Tb of the bent portion 32T is opposed to the side surface 301B of the optical member 301 (reference member 300). The side surface 301B of the optical member 301, the inner side surface 32Tb and the outer side surface 32Ta of the bent portion 32T, and the inner side surface 310A and the upper end surface 310B of the wall section 310 are flat surfaces respectively. The thin-walled portion 32S including the bent portion 32T of the second plate member 32 is slightly separated from the wall section 310, and a predetermined gap (interstice) is formed therebetween.

[0091] The areas of the upper surface 301A and the side surface 301B of the optical member 301 opposed to at least the bent portion 32T, and the inner side surface 310A and the upper end surface 310B of the wall section 310 are subjected to the liquid-repelling treatment to have the liquid repellence. The liquid-repelling treatment can be

performed, for example, by coating the liquid-repellent material such as the fluorine-based resin material and the acrylic resin material as described above.

[0092] The liquid 1, which flows into the space 370 between the reference member 301 and the bent portion 32T of the second plate member 32 (wall section 310), is recovered by a recovery section 380. In this embodiment, the recovery section 380 includes a vacuum system 383, a gas/liquid separator 381 which includes a tank capable of accommodating the liquid 1, and a flow passage 382 which is provided in the substrate table PT and which connects the space 370 and the gas/liquid separator 381. The liquid-repelling treatment is also performed to the inner wall surface of the flow passage 382.

[0093] It is conceived that the reference member 300 described above may be constructed to perform the operation for detecting the reference mark, for example, in a state in which the liquid immersion area AR2 of the liquid 1 is formed on the upper surface 301A of the reference member 300. However, the upper surface 301A is liquid-repellent. Therefore, the liquid 1 of the liquid immersion area AR2 on the upper surface 301A can be satisfactorily recovered after the completion of the operation for detecting the reference mark. It is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1 remains. Further, the side surface 301B of the optical

member 301 is liquid-repellent, and the inner side surface 32Tb of the bent portion 32T opposed to the side surface 301B is also liquid-repellent. Therefore, the liquid 1 hardly inflows into the gap K. Therefore, it is possible to avoid the inconvenience of the inflow of the liquid 1 into the space 370. Even if the liquid 1 inflows into the space 370, the liquid 1 can be satisfactorily recovered by the recovery section 380. Further, even if the liquid 1 inflows into the space 370, it is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1, which inflows into the space 370, rides across the wall section 310, and the liquid 1 inflows into the substrate table PT to cause the rust or the like, because the inner side surface 310A and the upper end surface 310B of the wall section 310 are liquid-repellent, and the second plate member 32 (bent portion 32T) opposed to the wall section 310 is also liquid-repellent. As described above, the wall section 310 functions as a liquid diffusion-preventing wall to avoid the diffusion of the liquid 1. A corner is formed as viewed in a sectional view by the bent portion 32T at the gap between the second plate member 32 and the wall section 310. The corner functions as a seal portion. Therefore, it is possible to reliably avoid the inflow of the liquid 1 into the substrate table PT.

[0094] Since the reference member 300 (optical member

301) is exchangeable, when the liquid repellence thereof is deteriorated, the reference member 300 may be exchanged with a new reference member 300 (having the sufficient liquid repellence).

[0095] When the reference member 300 is used, the measuring light beam is locally radiated onto the mark portion. Therefore, a plurality of identical reference marks may be formed on the reference member 300 beforehand. When the liquid repellence of the surface of the mark portion is deteriorated, another reference mark may be used. Alternatively, the marks may be alternately used for every measurement operation in order to lower the speed of the deterioration of the liquid repellence. Accordingly, it is possible to decrease the exchange frequency of the reference member 300. This procedure is especially effective, because the liquid repellence is quickly deteriorated at the portion including the reference mark MFM for which the measuring light beam having the same wavelength as the exposure wavelength is used.

[0096] Fig. 15 shows a sectional view illustrating the uneven illuminance sensor 400 provided on the substrate table PT. With reference to Fig. 15, the uneven illuminance sensor 400 includes an upper plate 401 which is formed of, for example, quartz glass, and an optical element 402 which is provided below the upper plate 401 and which is formed of, for example, quartz glass. In this

embodiment, the upper plate 401 and the optical element 402 are provided as an integrated body. In the following description, the upper plate 401 and the optical element 402 will be appropriately referred to as "optical member 404" in combination. The upper plate 401 and the optical element 402 are supported on the substrate table PT by the aid of a support section 403. The support section 403 has a continuous wall portion which surrounds the optical member 404. As described above, the uneven illuminance sensor 400 is arranged in the opening 32L provided for the second plate member 32, and the upper surface 401A is exposed. The optical member 404, which includes the upper plate 401 and the optical element 402, is detachable with respect to the substrate table PT, and the optical member 404 is exchangeable.

[0097] A pinhole 470, through which the light beam can pass, is provided on the upper plate 401. A thin film 460, which includes a light-shielding material such as chromium, is provided at portions on the upper plate 401 except for the pinhole 470. In this embodiment, an optical member formed of quartz glass is also provided in the pinhole 470. Accordingly, the thin film 460 is flush with the pinhole 470, and the upper surface 401A is a flat surface.

[0098] An optical sensor 450, which receives the light beam allowed to pass through the pinhole 470, is arranged below the optical member 404. The optical sensor 450 is

attached onto the substrate table PT. The optical sensor 450 outputs a light-receiving signal to the control unit CONT. In this arrangement, a space 405, which is surrounded by the support section 403, the substrate table PT, and the optical member 404, is a substantially tightly closed space. The liquid 1 does not inflow into the space 405. An optical system (optical element) may be arranged between the optical member 404 and the optical sensor 450.

[0099] A gap L, which is, for example, about 0.3 mm, is provided between the opening 32L and the uneven illuminance sensor 400 including the optical member 404 and the support section 403. The upper surface 401A of the uneven illuminance sensor 400 is a substantially flat surface which is provided to have approximately the same height as those of (be flush with) the surface of the substrate P, the surface 30A of the plate member 30, and the surface 32A of the second plate member 32.

[0100] Portions of the second plate member 32, which are disposed in the vicinity of the uneven illuminance sensor 400, are thin-walled. An end of the thin-walled portion 32S, of the thin-walled portion, which is disposed on the side of the uneven illuminance sensor 400, is bent downwardly to form a bent portion 32T. A wall section 310, which protrudes upwardly, is formed on the substrate table PT. The wall section 310 is provided outside the bent portion 32T in relation to the uneven illuminance sensor

400. The wall section 310 is formed continuously to surround the uneven illuminance sensor 400 (bent portion 32T). The outer side surface 32Ta of the bent portion 32T is opposed to the inner side surface 310A of the wall section 310. The inner side surface 32Tb of the bent portion 32T is opposed to the side surface 401B of the support section 403 and the optical member 404 of the uneven illuminance sensor 400. The side surface 401B, the inner side surface 32Tb and the outer side surface 32Ta of the bent portion 32T, and the inner side surface 310A and the upper end surface 310B of the wall section 310 are flat surfaces respectively. The thin-walled portion 32S including the bent portion 32T of the second plate member 32 is slightly separated from the wall section 310, and a predetermined gap (interstice) is formed therebetween.

[0101] The areas of the upper surface 401A and the side surface 401B of the uneven illuminance sensor 400 opposed to at least the bent portion 32T, and the inner side surface 310A and the upper end surface 310B of the wall section 310 are subjected to the liquid-repelling treatment to have the liquid repellence. The liquid-repelling treatment can be performed, for example, by coating the liquid-repellent material such as the fluorine-based resin material and the acrylic resin material as described above.

[0102] The liquid 1, which flows into a space 470 between the uneven illuminance sensor 400 and the bent

portion 32T of the second plate member 32 (wall section 310), is recovered by a recovery section 480. In this embodiment, the recovery section 480 includes a vacuum system 483, a gas/liquid separator 481 which includes a tank capable of accommodating the liquid 1, and a flow passage 482 which is provided in the substrate table PT and which connects the space 470 and the gas/liquid separator 481. The liquid-repelling treatment is also performed to the inner wall surface of the flow passage 482.

[0103] As for the uneven illuminance sensor 400 described above, the pinhole 470 is successively moved to a plurality of positions in the irradiation area (projection area) onto which the exposure light beam EL is radiated, for example, in a state in which the liquid immersion area AR2 of the liquid 1 is formed on the upper surface 401A of the uneven illuminance sensor 400. The upper surface 401A is liquid-repellent. Therefore, the liquid 1 of the liquid immersion area AR2 on the upper surface 401A can be satisfactorily recovered after the completion of the measurement of the uneven illuminance. It is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1 remains. Further, the side surface 401B of the uneven illuminance sensor 400 (optical member 404, support section 403) is liquid-repellent, and the inner side surface 32Tb of the bent portion 32T opposed to the side surface 401B is also liquid-repellent. Therefore,

the liquid 1 hardly inflows into the gap L. Therefore, it is possible to avoid the inconvenience of the inflow of the liquid 1 into the space 470. Even if the liquid 1 inflows into the space 470, the liquid 1 can be satisfactorily recovered by the recovery section 480. Further, even if the liquid 1 inflows into the space 470, it is possible to avoid the inconvenience which would be otherwise caused such that the liquid 1, which inflows into the space 470, rides across the wall section 310, and the liquid 1 inflows into the substrate table PT to cause the rust or the like, because the inner side surface 310A and the upper end surface 310B of the wall section 310 are liquid-repellent, and the second plate member 32 (bent portion 32T) opposed to the wall section 310 is also liquid-repellent. A corner is formed as viewed in a sectional view by the bent portion 32T at the gap between the second plate member 32 and the wall section 310. The corner functions as a seal portion. Therefore, it is possible to reliably avoid the inflow of the liquid 1 into the substrate table PT.

[0104] Since the optical member 404 is exchangeable, when the liquid repellence thereof is deteriorated, the optical member 404 may be exchanged with a new optical member 404 (having the sufficient liquid repellence).

[0105] The spatial image-measuring sensor 500 is constructed substantially equivalently to the uneven illuminance sensor 400. Therefore, any detailed

explanation thereof will be omitted. However, the spatial image-measuring sensor 500 also has an optical member constructed of an optical element and an upper plate supported by the aid of a support section on the substrate table PT. A slit 570 through which the light beam can pass, and a thin film which is formed of a light-shielding material to cover portions other than the slit are provided on an upper surface 501A of the spatial image-measuring sensor 500. An optical sensor, which receives the light beam allowed to pass through the slit 570, is provided below the optical member. The optical member, which has the slit 570, is exchangeable depending on the deterioration of the liquid repellence.

[0106] In the embodiment explained with reference to Figs. 14 and 15, the inflow of the liquid 1 is avoided by providing the liquid repellence for the surfaces of the members for forming the gaps K, L. However, the inflow of the liquid 1 into the gap can be avoided by similarly providing the liquid repellence for the gap existing on the upper surface of the substrate table PT, without being limited to the gaps disposed around the measuring member and the sensor. Alternatively, a seal member, which is formed of a resin or the like, may be arranged in the gap K, L to avoid the inflow of the liquid 1. Further alternatively, the gap K, L may be filled with a liquid (for example, vacuum grease or magnetic fluid) to provide

the liquid seal function so that the inflow of the liquid 1 is avoided. In this arrangement, it is preferable that the sealing liquid is hardly dissolved or eluted in the liquid 1. Of course, it goes without saying that the countermeasures to avoid the inflow of the liquid may be used in combination.

[0107] In the embodiment described above, the exchange is performed when the liquid repellence of the surface of the member is deteriorated. However, when a certain member is exchanged, other members, which will reach the exchange timing soon, may be simultaneously exchanged.

[0108] In order to recover the liquid (water) more reliably, it is desirable that the contact angle with respect to the liquid (water) is larger than about 80°, desirably not less than 100° (contact angle of polytetrafluoroethylene described above with respect to the liquid (water) is about 110°), for example, for the surface of the substrate table PT, i.e., the surface of the plate member 30, the surface of the second plate member 32, and the surface of the reference member 300.

[0109] It is desirable that the photosensitive material (resist for the ArF exposure light beam) to be used, with which the surface of the substrate P is coated, has the contact angle with respect to the liquid (water) that is larger than about 80°. Of course, when the KrF excimer

laser light beam is used as the exposure light beam, it is desirable to use, as a resist for the KrF exposure light beam, a material which has the contact angle with respect to the liquid that is larger than 80°.

[0110] The present invention is also applicable to a twin-stage type exposure apparatus which is provided with two substrate stages (substrate tables) for holding the substrate P, as disclosed in Japanese Patent Application Laid-open Nos. 10-163099 and 10-214783, and Published Japanese Translation of PCT International Publication for Patent Application No. 2000-505958, etc.

[0111] Fig. 16 shows a schematic arrangement of a twin-stage type exposure apparatus. The twin-stage type exposure apparatus includes first and second substrate stages PST1, PST2 which are movable on a common base 54 independently respectively. The first and second substrate stages PST1, PST2 have first and second substrate tables PT1, PT2 respectively. The plate member 30 and the second plate member 32 are provided exchangeably on each of the first and second substrate tables PT1, PT2. The twin-stage type exposure apparatus includes an exposure station ST1 and a measuring/exchange station ST2. The exposure station ST1 is provided with the projection optical system PL. The substrate alignment system, the focus/leveling-detecting system and the like are provided on the measuring/exchange station ST2 (not shown in Fig. 16). The liquid immersion

exposure process is performed for a substrate P held on the first substrate table PT1 in the exposure station ST1, during which the substrate P is loaded/unloaded with respect to the second substrate stage PST2 (second substrate table PT2) together with the plate member 30 in the measuring/exchange station ST2. In the measuring/exchange station ST2, the measuring operation (focus-detecting operation, alignment operation) is performed for a substrate P disposed on the second substrate stage PST2 concurrently with the liquid immersion exposure in the exposure station ST1. After the completion of the measuring operation, the second substrate stage PST2 is moved to the exposure station ST2, and the liquid immersion exposure process is performed for the substrate P disposed on the second substrate stage PST2.

[0112] As described above, in the case of the twin-stage type exposure apparatus, it is possible to perform not only the substrate exchange and the measuring process but also the exchange of the plate member 30 on the other stage during the period in which the liquid immersion exposure process is performed on one stage. Therefore, it is possible to improve the throughput of the exposure process.

[0113] The respective embodiments described above have been explained such that the plate member 30 or the like is exchanged depending on the liquid repellence thereof. However, it goes without saying that the plate member 30 or

the like can be exchanged for any reason other then the deterioration of the liquid repellence, for example, when the plate member 30 or the like is damaged or polluted due to any cause.

[0114] As described above, the liquid 1 is composed of pure water in this embodiment. Pure water is advantageous in that pure water is available in a large amount with ease, for example, in the semiconductor production factory, and pure water exerts no harmful influence, for example, on the optical element (lens) and the photoresist on the substrate P. Further, pure water exerts no harmful influence on the environment, and the content of impurity is extremely low. Therefore, it is also expected to obtain the function to wash the surface of the substrate P and the surface of the optical element provided at the end surface of the projection optical system PL. When the purity of pure water supplied from the factory or the like is low, it is also appropriate that the exposure apparatus is provided with an ultrapure water-producing unit.

[0115] It is approved that the refractive index n of pure water (water) with respect to the exposure light beam EL having a wavelength of about 193 nm is approximately in an extent of 1.44. When the ArF excimer laser beam (wavelength: 193 nm) is used as the light source of the exposure light beam EL, then the wavelength is shortened on the substrate P by 1/n, i.e., to about 134 nm, and a high

resolution is obtained. Further, the depth of focus is magnified about n times, i.e., about 1.44 times as compared with the value obtained in the air. Therefore, when it is enough to secure an approximately equivalent depth of focus as compared with the case of the use in the air, it is possible to further increase the numerical aperture of the projection optical system PL. Also in this viewpoint, the resolution is improved.

[0116] When the liquid immersion method is used as described above, the numerical aperture NA of the projection optical system is 0.9 to 1.3 in some cases. When the numerical aperture NA of the projection optical system is increased as described above, the image formation performance is sometimes deteriorated by the polarization effect with the random polarized light beam having been hitherto used as the exposure light beam. Therefore, it is desirable to use the polarized illumination. In this case, the following procedure is preferred. That is, the linear polarized illumination is effected, which is adjusted to the longitudinal direction of the line pattern of the line-and-space pattern of the mask (reticle) so that a large amount of diffracted light of the S-polarized component (TE-polarized component), i.e., the component in the polarization direction along the longitudinal direction of the line pattern is allowed to outgo from the pattern of the mask (reticle). When the space between the projection

optical system PL and the resist coated on the surface of the substrate P is filled with the liquid, the diffracted light of the S-polarized component (TE-polarized component), which contributes to the improvement in the contrast, has the transmittance through the resist surface that is raised to be high as compared with a case in which the space between the projection optical system PL and the resist coated on the surface of the substrate P is filled with the air (gas). Therefore, even when the numerical aperture NA of the projection optical system exceeds 1.0, it is possible to obtain the high image formation performance. It is more effective to make appropriate combination, for example, with the phase shift mask and/or the oblique incidence illumination method (especially the dipole illumination method) adjusted to the longitudinal direction of the line pattern as disclosed in Japanese Patent Application Laid-open No. 6-188169.

[0117] Further, for example, when the ArF excimer laser beam is used as the exposure light beam, and the substrate P is exposed with a fine line-and-space pattern (for example, line-and-space of about 25 to 50 nm) by using the projection optical system PL having a reduction magnification of about 1/4, then the mask M functions as a polarizing plate on account of the Wave Guide effect depending on the structure of the mask M (for example, the pattern fineness and the chromium thickness), and a large

amount of the diffracted light beam of the S-polarized component (TE-polarized component) is radiated from the mask M as compared with the diffracted light beam of the P-polarized component (TM-polarized component) which lowers the contrast. In such a situation, it is desirable that the linear polarized illumination is used as described above. However, the high resolution performance can be obtained even when the numerical aperture NA of the projection optical system PL is large, for example, 0.9 to 1.3 even when the mask M is illuminated with the random polarized light beam. When the substrate P is exposed with an extremely fine line-and-space pattern on the mask M, there is also such a possibility that the P-polarized component (TM-polarized component) may be larger than the S-polarized component (TE-polarized component) on account of the Wire Grid effect. However, for example, when the ArF excimer laser beam is used as the exposure light beam, and the substrate P is exposed with a line-and-space pattern larger than 25 nm by using the projection optical system PL having a reduction magnification of about 1/4, then a large amount of the diffracted light beam of the S-polarized component (TE-polarized component) is radiated from the mask M as compared with the P-polarized component (TM-polarized component). Therefore, the high resolution performance can be obtained even when the numerical aperture NA of the projection optical system PL is large,

for example, 0.9 to 1.3.

[0118] Further, it is also effective to use a combination of the oblique incidence illumination method and the polarized illumination method in which the linear polarization is effected in a tangential (circumferential) direction of a circle having a center of the optical axis as disclosed in Japanese Patent Application Laid-open No. 6-53120 as well as the linear polarized illumination (S-polarized illumination) adjusted to the longitudinal direction of the line pattern of the mask (reticle). In particular, when the pattern of the mask (reticle) includes not only the line pattern which extends in a predetermined one direction but the pattern also includes line patterns which extend in a plurality of directions in a mixed manner, then the high image formation performance can be obtained even when the numerical aperture NA of the projection optical system is large, by using, in combination, the zonal illumination method and the polarized illumination method in which the linear polarization is effected in a tangential direction of a circle having a center of the optical axis as disclosed in Japanese Patent Application Laid-open No. 6-53120 as well.

[0119] In this embodiment, the optical element 2 is attached to the end portion of the projection optical system PL. The lens can be used to adjust the optical characteristics of the projection optical system PL,

including, for example, the aberration (for example, spherical aberration and comatic aberration). The optical element, which is attached to the end portion of the projection optical system PL, may be an optical plate to be used to adjust the optical characteristic of the projection optical system PL. Alternatively, the optical element may be a plane parallel plate through which the exposure light beam EL is transmissive.

[0120] When the pressure, which is generated by the flow of the liquid 1, is large between the substrate P and the optical element disposed at the end portion of the projection optical system PL, it is also allowable that the optical element is tightly fixed so that the optical element is not moved by the pressure, rather than allowing the optical element to be exchangeable.

[0121] This embodiment is constructed such that the space between the projection optical system PL and the surface of the substrate P is filled with the liquid 1. However, for example, another arrangement may be adopted such that the space is filled with the liquid 1 in a state in which a cover glass constructed of a plane parallel plate is attached to the surface of the substrate P.

[0122] The liquid 1 is water in this embodiment. However, the liquid 1 may be any liquid other than water. For example, when the light source of the exposure light beam EL is the F_2 laser, the F_2 laser beam is not

transmitted through water. Therefore, in this case, liquids preferably usable as the liquid 1 may include, for example, a fluorine-based fluid such as fluorine-based oil and perfluoropolyether (PFPE) through which the F_2 laser beam is transmissive. In this case, the portion to make contact with the liquid 1 is subjected to the liquid-attracting treatment by forming a thin film, for example, with a substance having a molecular structure of small polarity including fluorine. Alternatively, other than the above, it is also possible to use, as the liquid 1, liquids (for example, cedar oil) which have the transmittance with respect to the exposure light beam EL, which have the refractive index as high as possible, and which are stable against the photoresist coated on the surface of the substrate P and the projection optical system PL. Also in this case, the surface treatment is performed depending on the polarity of the liquid 1 to be used.

[0123] The substrate P, which is usable in the respective embodiments described above, is not limited to the semiconductor wafer for producing the semiconductor device. Those applicable include, for example, the glass substrate for the display device, the ceramic wafer for the thin film magnetic head, and the master plate (synthetic quartz, silicon wafer) for the mask or the reticle to be used for the exposure apparatus.

[0124] As for the exposure apparatus EX, the present

invention is also applicable to the scanning type exposure apparatus (scanning stepper) based on the step-and-scan system for performing the scanning exposure for the pattern of the mask M by synchronously moving the mask M and the substrate P as well as the projection exposure apparatus (stepper) based on the step-and-repeat system for performing the full field exposure for the pattern of the mask M in a state in which the mask M and the substrate P are allowed to stand still, while successively step-moving the substrate P. The present invention is also applicable to the exposure apparatus based on the step-and-stitch system in which at least two patterns are partially overlaid and transferred on the substrate P.

[0125] The embodiments described above adopt the exposure apparatus in which the space between the projection optical system PL and the substrate P is locally filled with the liquid. However, the present invention is also applicable to a liquid immersion exposure apparatus in which the stage for holding the substrate as the exposure objective is moved in the liquid tank as disclosed in Japanese Patent Application Laid-open No. 6-124873.

[0126] As for the type of the exposure apparatus EX, the present invention is not limited to the exposure apparatus for the semiconductor device production apparatus for exposing the substrate P with the semiconductor device pattern. The present invention is also widely applicable,

for example, to the exposure apparatus for producing the liquid crystal display device or for producing the display as well as the exposure apparatus for producing, for example, the thin film magnetic head, the image pickup device (CCD), the reticle, or the mask.

[0127] When the linear motor (See United States Patent Nos. 5,623,853 or 5,528,118) is used for the substrate stage PST and/or the mask stage MST, it is allowable to use any one of those of the air floating type based on the use of the air bearing and those of the magnetic floating type based on the use of the Lorentz's force or the reactance force. Each of the stages PST, MST may be either of the type in which the movement is effected along the guide or of the guideless type in which no guide is provided.

[0128] As for the driving mechanism for each of the stages PST, MST, it is also allowable to use a plane motor in which a magnet unit provided with two-dimensionally arranged magnets and an armature unit provided with two-dimensionally arranged coils are opposed to one another, and each of the stages PST, MST is driven by the electromagnetic force. In this arrangement, any one of the magnet unit and the armature unit is connected to the stage PST, MST, and the other of the magnet unit and the armature unit is provided on the side of the movable surface of the stage PST, MST.

[0129] The reaction force, which is generated in

accordance with the movement of the substrate stage PST, may be mechanically released to the floor (ground) by using a frame member so that the reaction force is not transmitted to the projection optical system PL as disclosed in Japanese Patent Application Laid-open No. 8-166475 (United States Patent No. 5,528,118).

The reaction force, which is generated in accordance with the movement of the mask stage MST, may be mechanically released to the floor (ground) by using a frame member so that the reaction force is not transmitted to the projection optical system PL as disclosed in Japanese Patent Application Laid-open No. 8-330224 (U.S. patent application serial No. 08/416,558).

[0130] As described above, the exposure apparatus EX according to the embodiment of the present invention is produced by assembling the various subsystems including the respective constitutive elements as defined in claims so that the predetermined mechanical accuracy, the electric accuracy, and the optical accuracy are maintained. In order to secure the various accuracies, those performed before and after the assembling include the adjustment for achieving the optical accuracy for the various optical systems, the adjustment for achieving the mechanical accuracy for the various mechanical systems, and the adjustment for achieving the electric accuracy for the various electric systems. The steps of assembling the

various subsystems into the exposure apparatus include, for example, the mechanical connection, the wiring connection of the electric circuits, and the piping connection of the air pressure circuits in correlation with the various subsystems. It goes without saying that the steps of assembling the respective individual subsystems are performed before performing the steps of assembling the various subsystems into the exposure apparatus. When the steps of assembling the various subsystems into the exposure apparatus are completed, the overall adjustment is performed to secure the various accuracies as the entire exposure apparatus. It is desirable that the exposure apparatus is produced in a clean room in which, for example, the temperature and the cleanness are managed.

[0131] As shown in Fig. 17, the microdevice such as the semiconductor device is produced by performing, for example, a step 201 of designing the function and the performance of the microdevice, a step 202 of manufacturing a mask (reticle) based on the designing step, a step 203 of producing a substrate as a base material for the device, an exposure process step 204 of exposing the substrate with a pattern of the mask by using the exposure apparatus EX of the embodiment described above, a step 205 of assembling the device (including a dicing step, a bonding step, and a packaging step), and an inspection step 206.

[BRIEF EXPLANATION OF THE DRAWINGS]

[0132]

[Fig. 1] Fig. 1 shows a schematic arrangement illustrating an embodiment of an exposure apparatus of the present invention.

[Fig. 2] Fig. 2 shows a schematic plan view illustrating a liquid supply mechanism and a liquid recovery mechanism.

[Fig. 3] Fig. 3 shows a plan view illustrating a substrate table.

[Fig. 4] Fig. 4 shows a plan view illustrating the substrate table in a state in which a substrate is held.

[Fig. 5] Fig. 5 shows a sectional view illustrating the substrate table.

[Fig. 6] Fig. 6 schematically shows that respective members are detachable with respect to the substrate table.

[Fig. 7] Figs. 7(a) to 7(d) schematically show an example of the operation of the exposure apparatus of the present invention.

[Fig. 8] Figs. 8(a) to 8(d) schematically show an example of the operation of the exposure apparatus of the present invention.

[Fig. 9] Fig. 9 shows a plan view illustrating a substrate-holding member transported by a transport unit.

[Fig. 10] Fig. 10 shows a sectional view illustrating another embodiment of a substrate table.

[Fig. 11] Figs. 11(a) and 11(b) show a schematic

arrangement illustrating another embodiment of an exposure apparatus of the present invention.

[Fig. 12] Figs. 12(a) and 12(b) show another embodiment of a substrate-holding member.

[Fig. 13] Figs. 13(a) to 13(d) schematically show another example of the operation of the exposure apparatus of the present invention.

[Fig. 14] Fig. 14 shows a schematic arrangement illustrating another embodiment of an exposure apparatus of the present invention.

[Fig. 15] Fig. 15 shows a schematic arrangement illustrating another embodiment of an exposure apparatus of the present invention.

[Fig. 16] Fig. 16 shows a schematic arrangement illustrating another embodiment of an exposure apparatus of the present invention.

[Fig. 17] Fig. 17 shows a flow chart illustrating exemplary steps of producing a semiconductor device.

[Fig. 18] Fig. 18 schematically explains a problem involved in the conventional technique.

[LEGEND OF REFERENCE NUMERALS]

[0133]

1: liquid

10: liquid supply mechanism

20: liquid recovery mechanism

30: plate member

30A: flat surface (flat portion)

72: suction hole (attachment/detachment mechanism)

74: lifting member (attachment/detachment mechanism)

AR1: projection area

AR2: liquid immersion area

EL: exposure light beam

EX: exposure apparatus

P: substrate

PL: projection optical system

PST: substrate stage

PT: substrate table

[TITLE OF THE DOCUMENT] Abstract

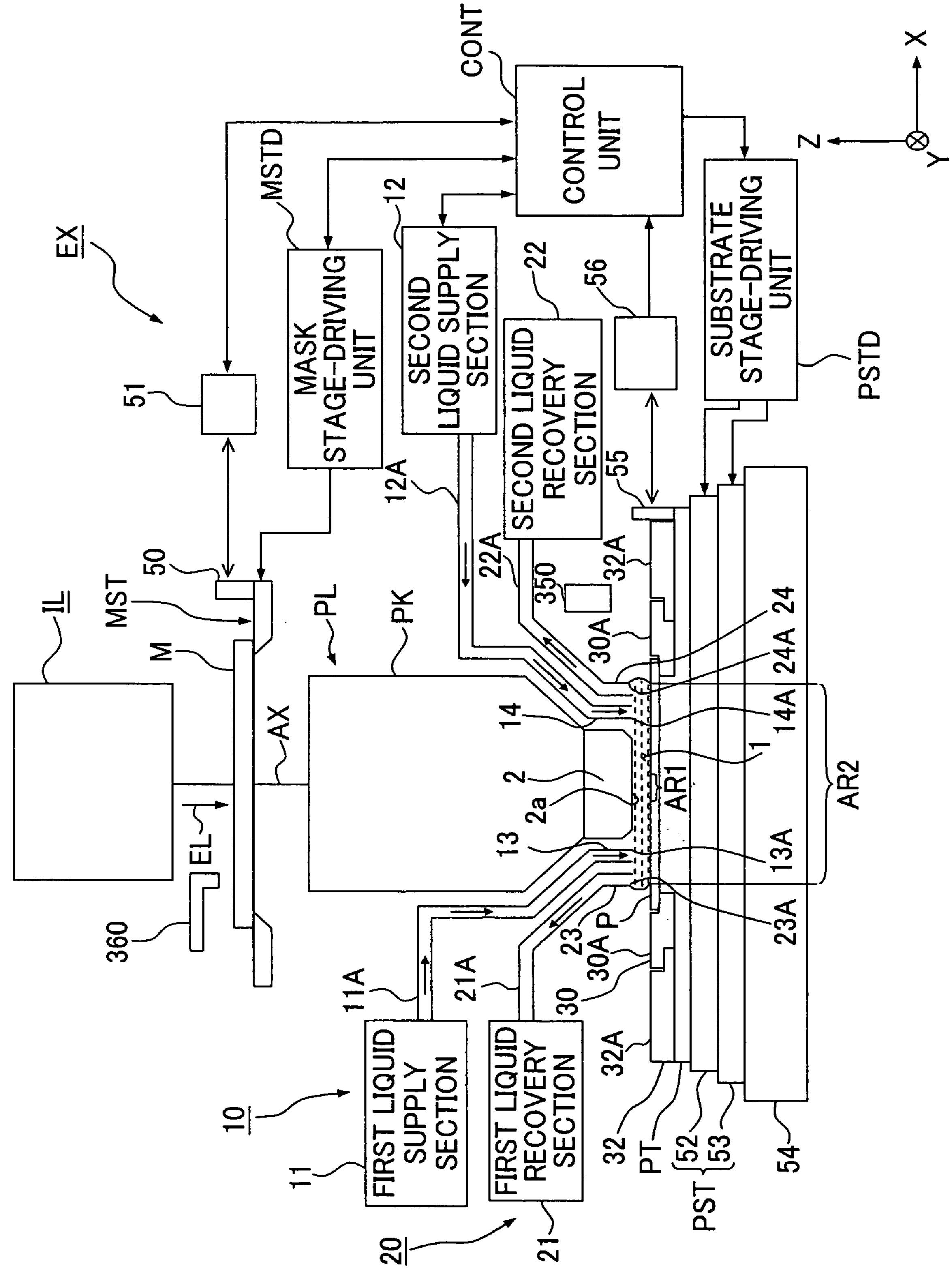
[ABSTRACT]

[TASK] To provide an exposure apparatus, an exposure method, and a method for producing device, in which it is possible to prevent a liquid from remaining on a substrate table, and it is possible to maintain a satisfactory exposure accuracy.

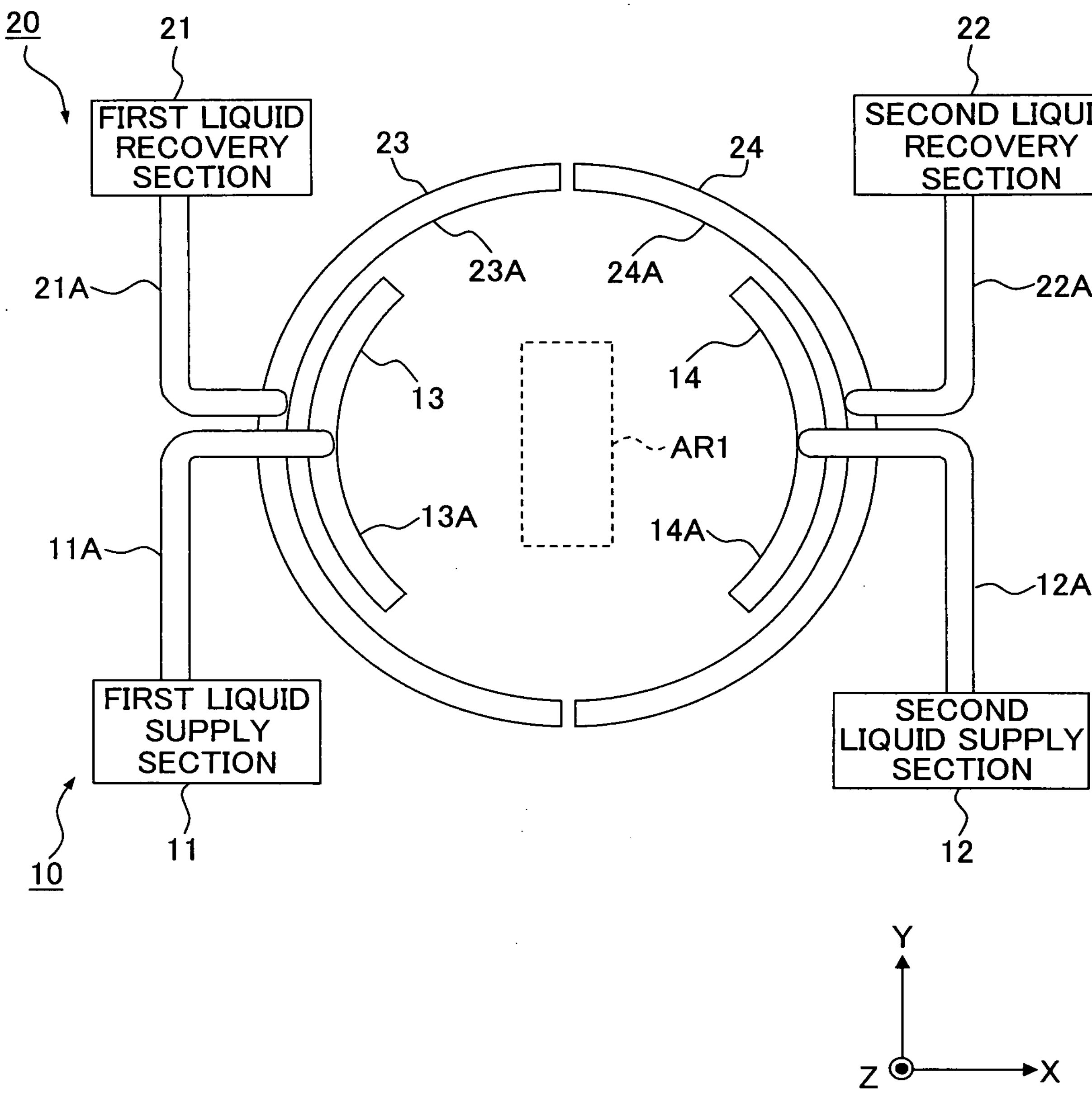
[SOLUTION TO THE TASK] Exposure apparatus EX exposes a substrate P by irradiating an exposure light beam EL onto the substrate P via a projection optical system PL and a liquid 1. The exposure apparatus EX is provided with a substrate table PT which holds the substrate P. The substrate table PT includes a plate member 30 having a liquid-repellent flat surface 30A. The plate member 30 is provided exchangeably.

[SELECTED DRAWINGS] Fig. 1

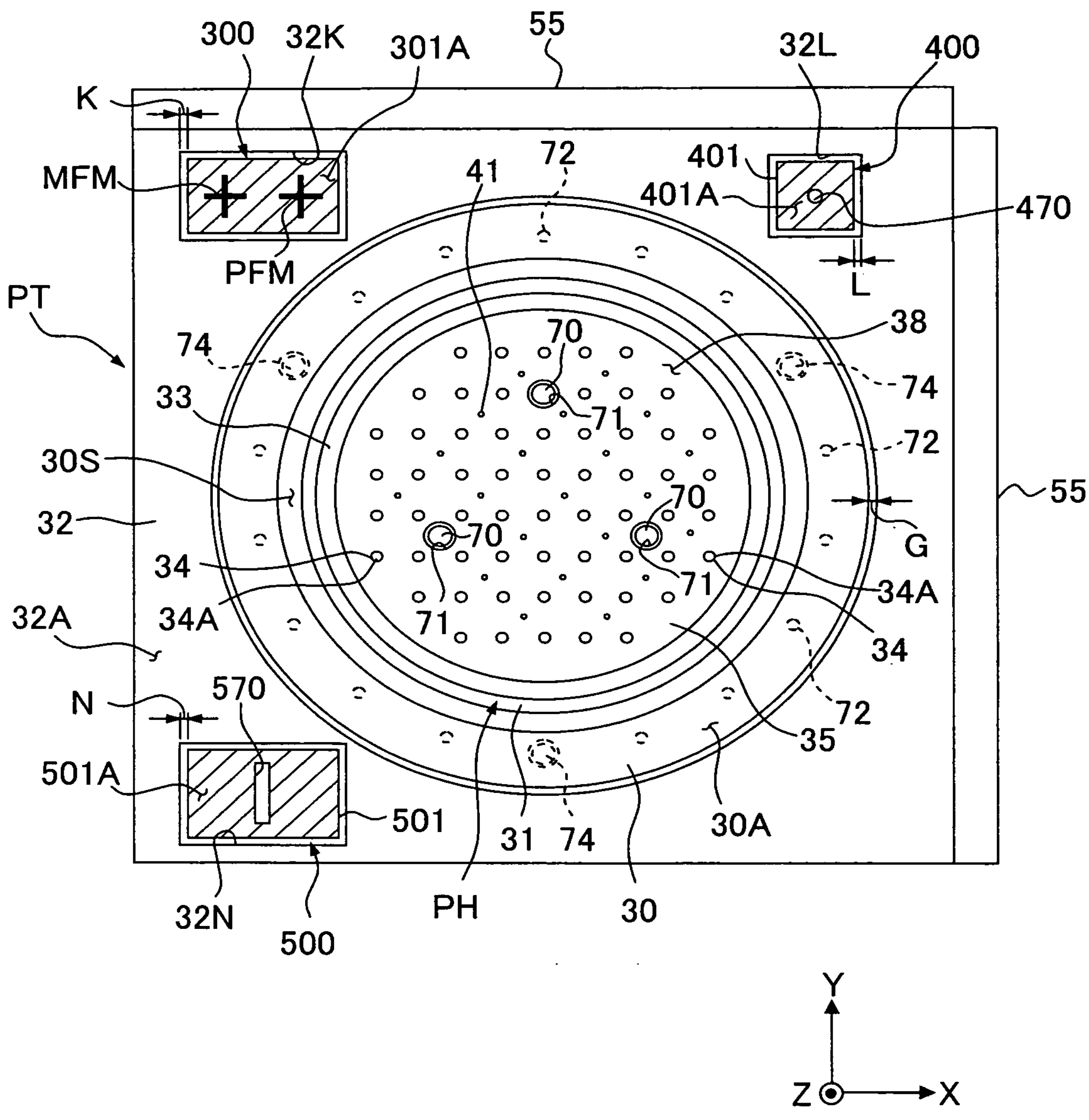
【Title of the Document】Drawing
【Fig. 1】



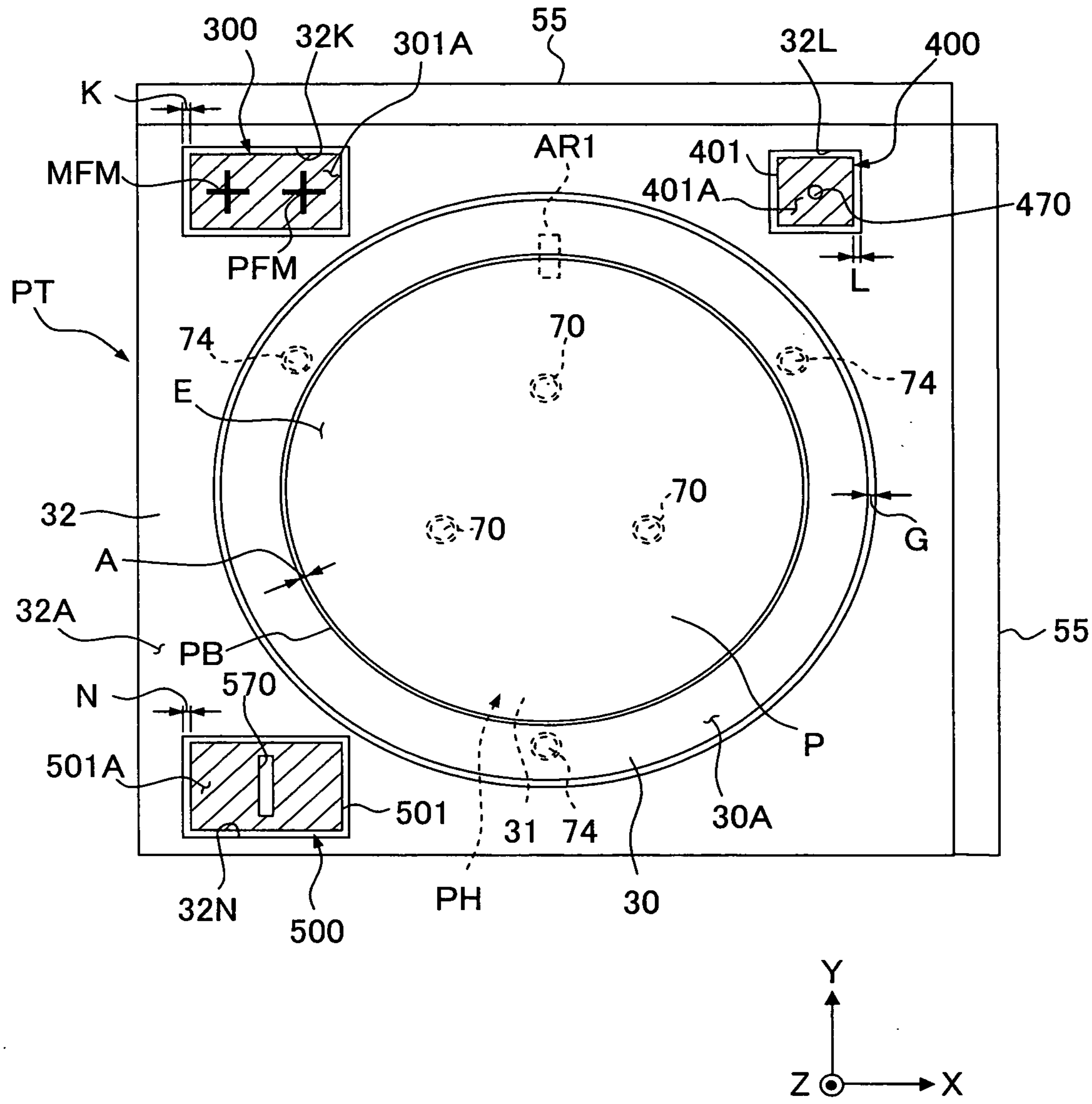
【Fig. 2】


20
21
FIRST LIQUID RECOVERY SECTION
23
24
22
SECOND LIQUID RECOVERY SECTION
21A
23A
24A
22A
13
14
AR1
13A
14A
11A
12A
FIRST LIQUID SUPPLY SECTION
SECOND LIQUID SUPPLY SECTION
10
11
12
Y
Z
X

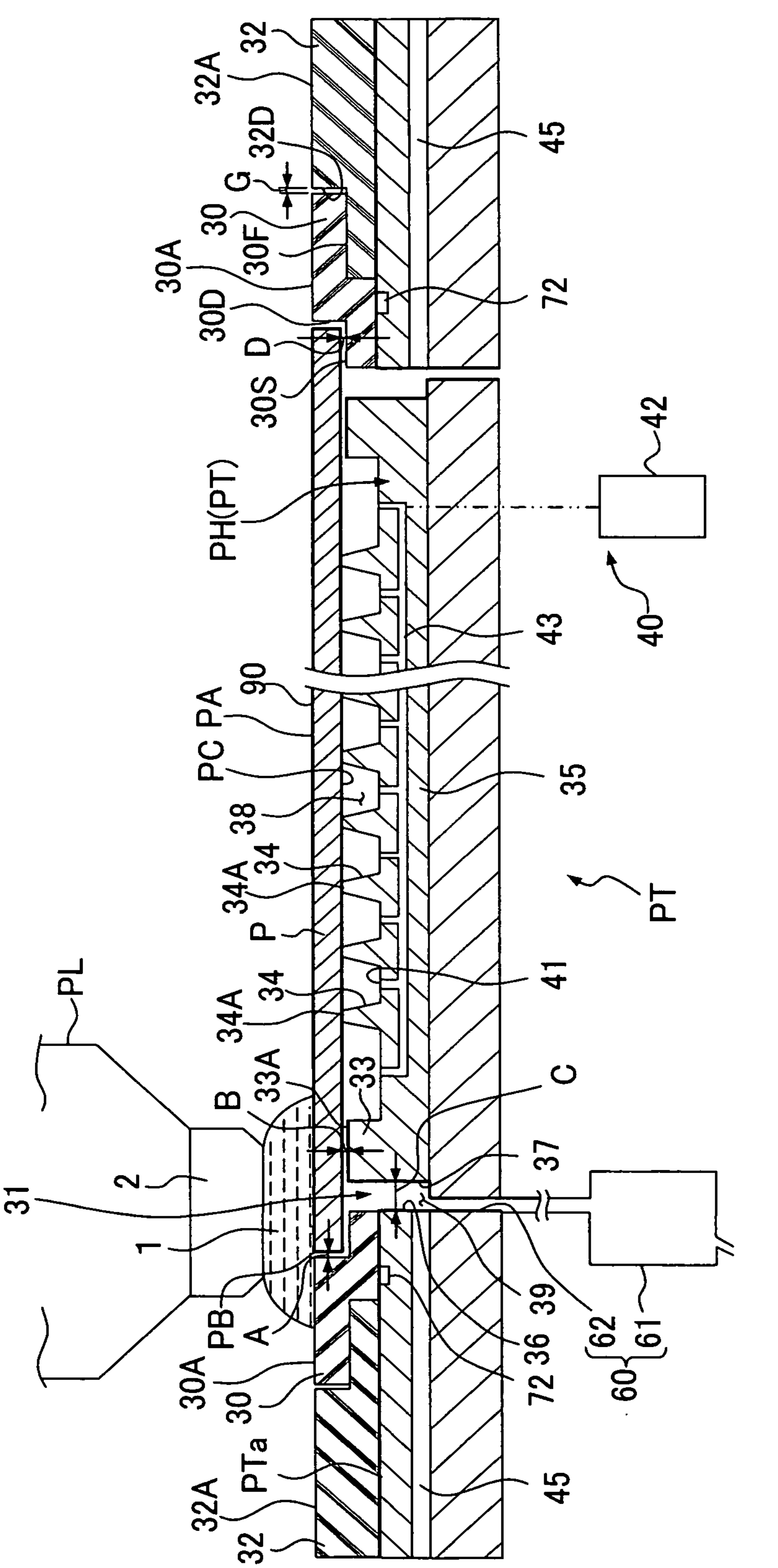
【Fig. 3】


300
32K
301A
55
32L
400
K
MFM
PFM
72
41
401
401A
470
L
PT
74
70
38
33
71
30S
72
32
70
55
G
70
34
71
34A
34A
71
32A
34
N
570
35
72
501A
501
31
74
30A
PH
30
32N
500
Y
Z
X

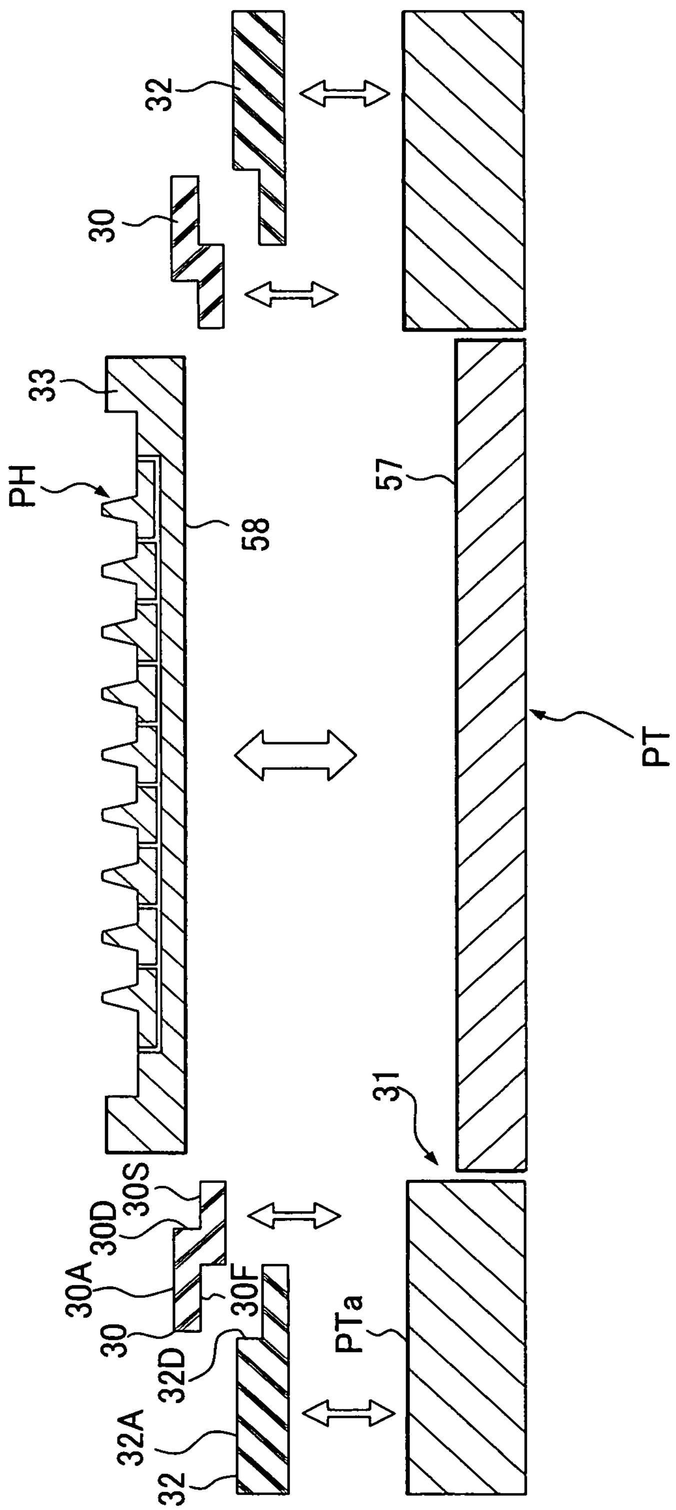
【Fig. 4】


300
32K
301A
55
32L
400
K
MFM
AR1
401
401A
470
PFM
L
PT
70
74
74
E
70
32
70
G
A
32A
PB
55
N
570
P
501A
501
31
74
30A
32N
500
PH
30
Y
Z
X

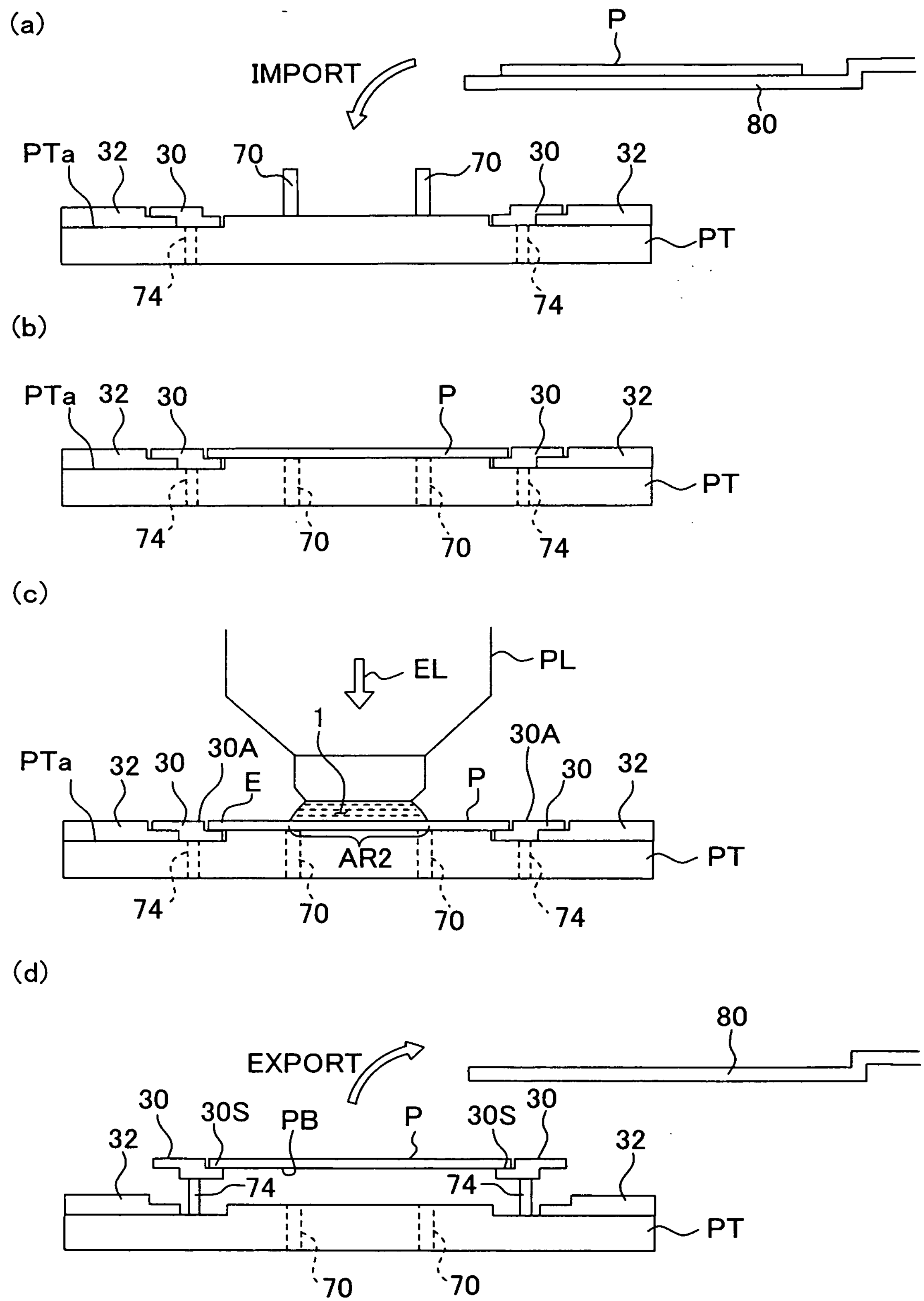
【Fig. 5】


32
32A
32D
45
G
30
30F
30A
72
30D
D
30S
42
PH(PT)
40
43
90
PC PA
35
38
34
34A
P
PT
41
PL
B
33A
33
C
2
37
31
1
39
62
PB
A
36
61
60
30A
30
72
PTa
45
32A
32

【Fig. 6】

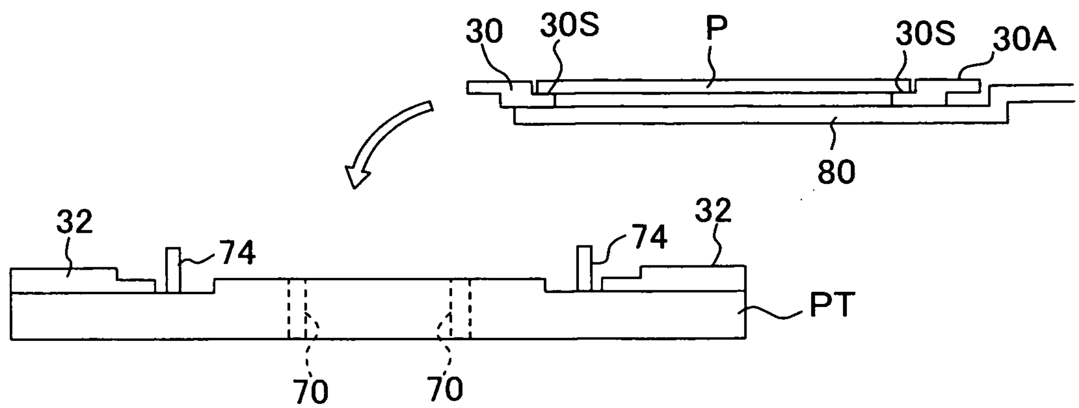


【Fig. 7】

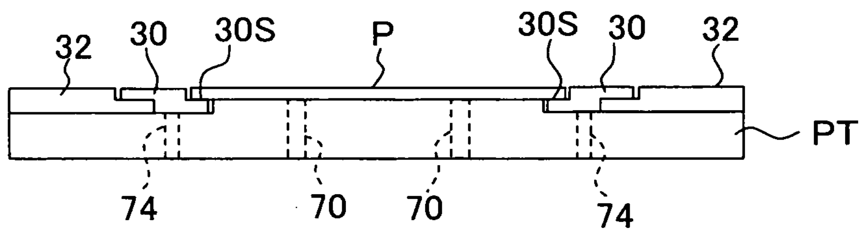

(a)
IMPORT
P
80
PTa
32
30
70
70
30
32
PT
74
74
(b)
PTa
32
30
P
30
32
PT
74
70
70
74
(c)
EL
PL
1
30A
30A
PTa
32
30
E
P
30
32
AR2
PT
74
70
70
74
(d)
80
EXPORT
30
30S
PB
P
30S
30
32
32
74
74
PT
70
70

【Fig. 8】

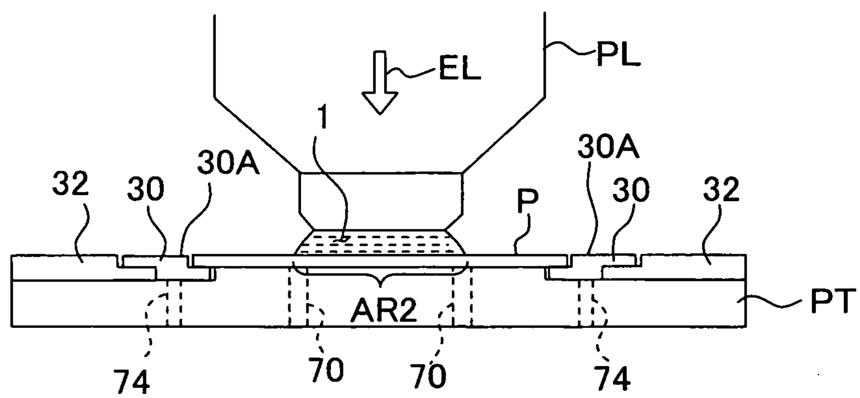
(a)


30
30S
P
30S
30A
80
32
74
74
32
PT
70
70

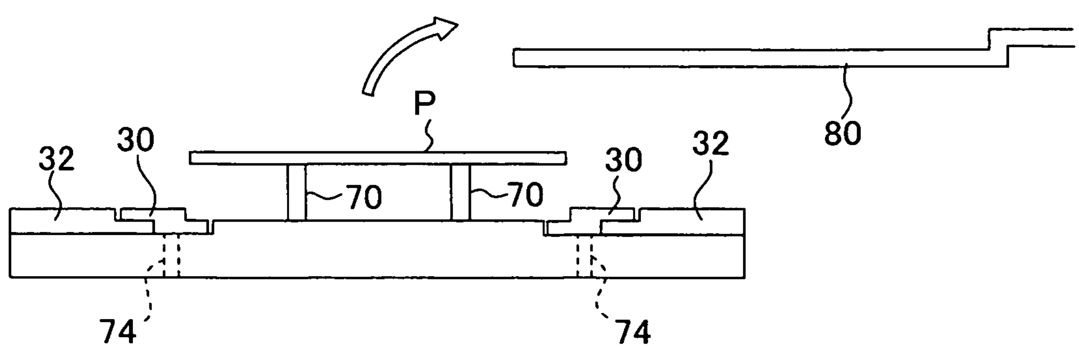
(b)


32
30
30S
P
30S
30
32
PT
74
70
70
74

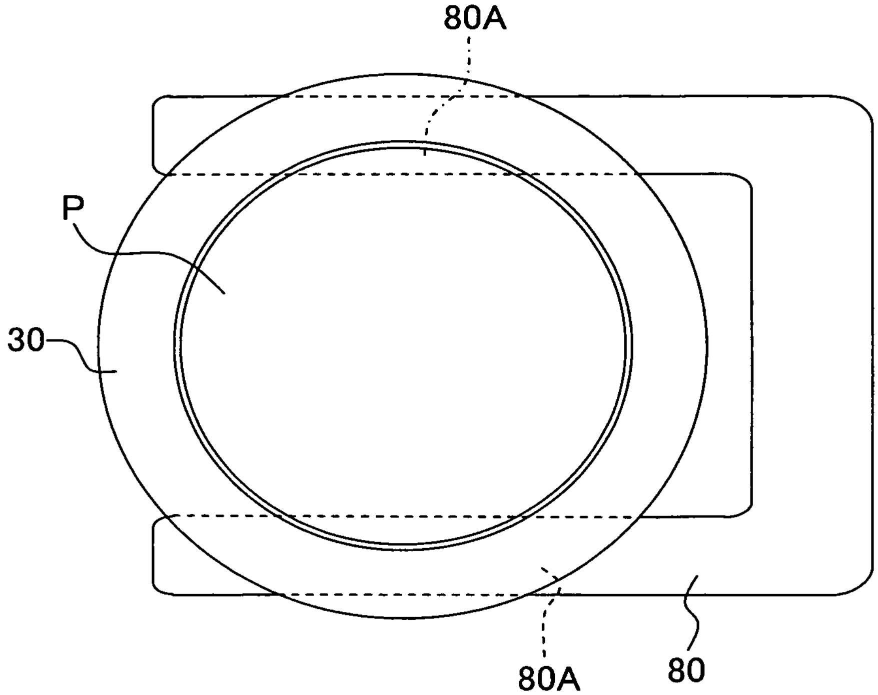
(c)


EL
PL
1
32
30
30A
P
30A
30
32
AR2
PT
74
70
70
74

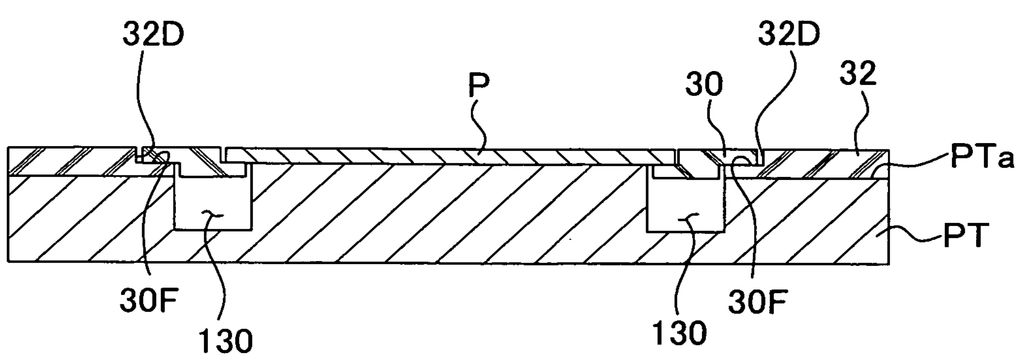
(d)


P
80
32
30
30
32
70
70
74
74

【Fig. 9】

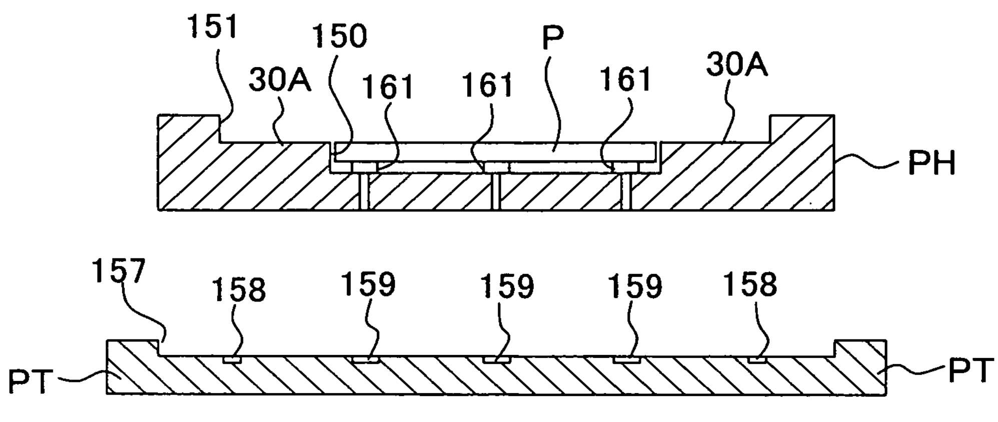


【Fig. 10】

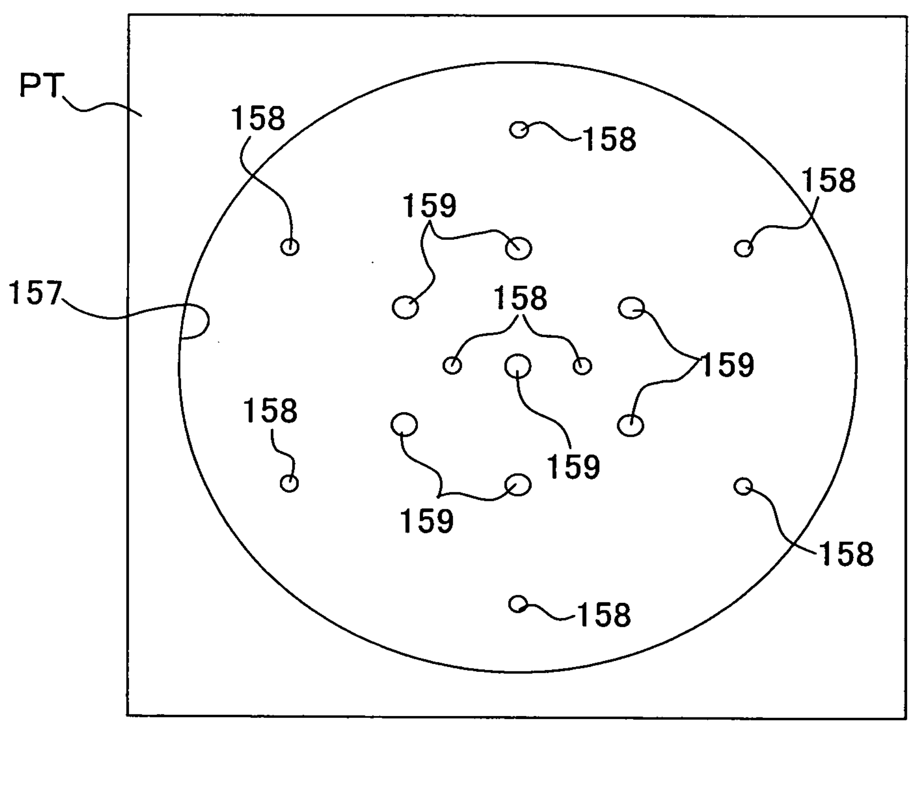


【Fig. 11】

(a)

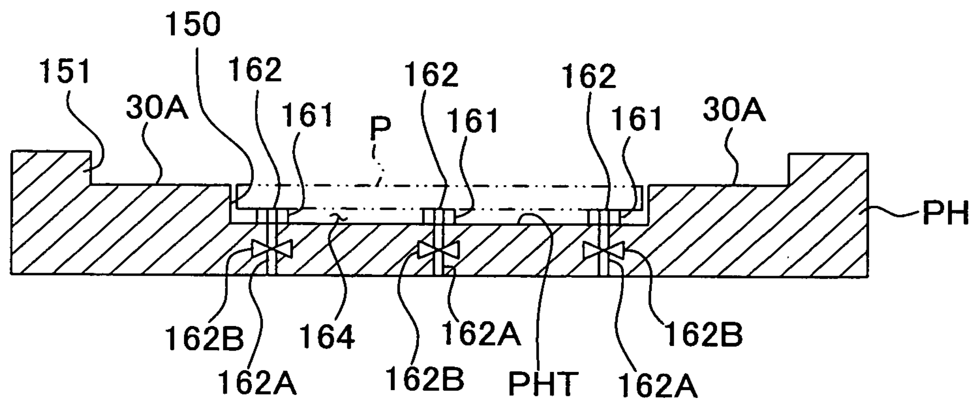

151
150
P
30A
161
161
161
30A
PH
157
158
159
159
159
158
PT
PT

(b)

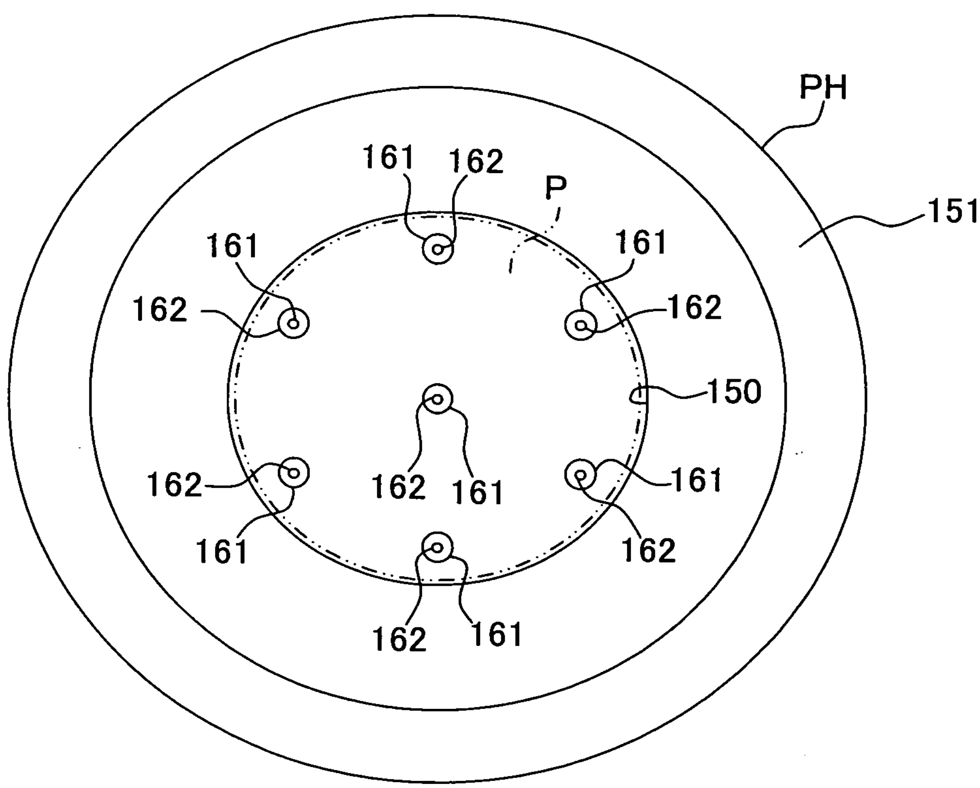

PT
158
158
158
159
157
158
159
158
159
159
158
158
158

【Fig. 12】

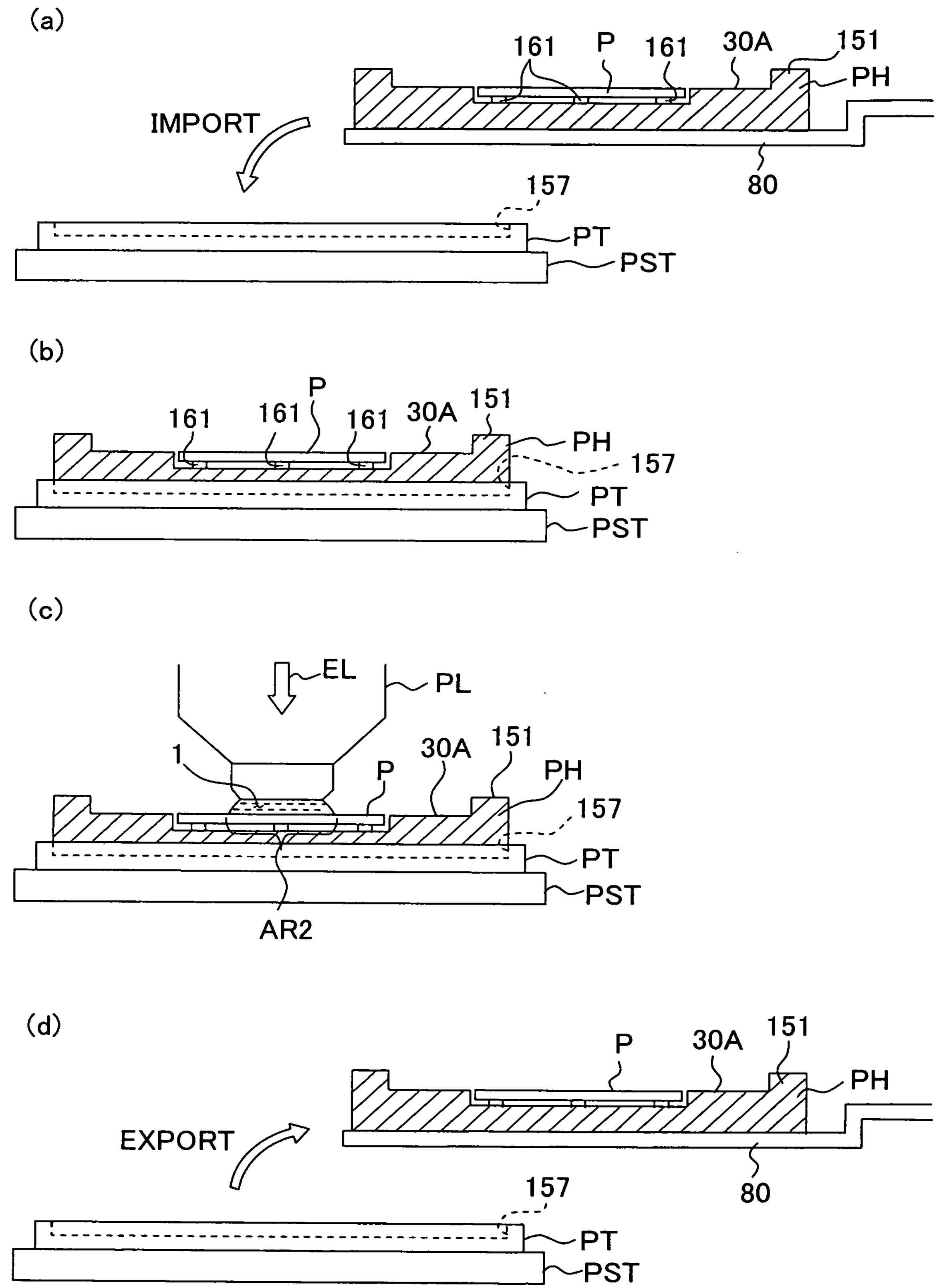
(a)


150
151
30A
162
161
P
162
161
162
161
30A
PH
162B
164
162A
162B
162A
162B
PHT
162A

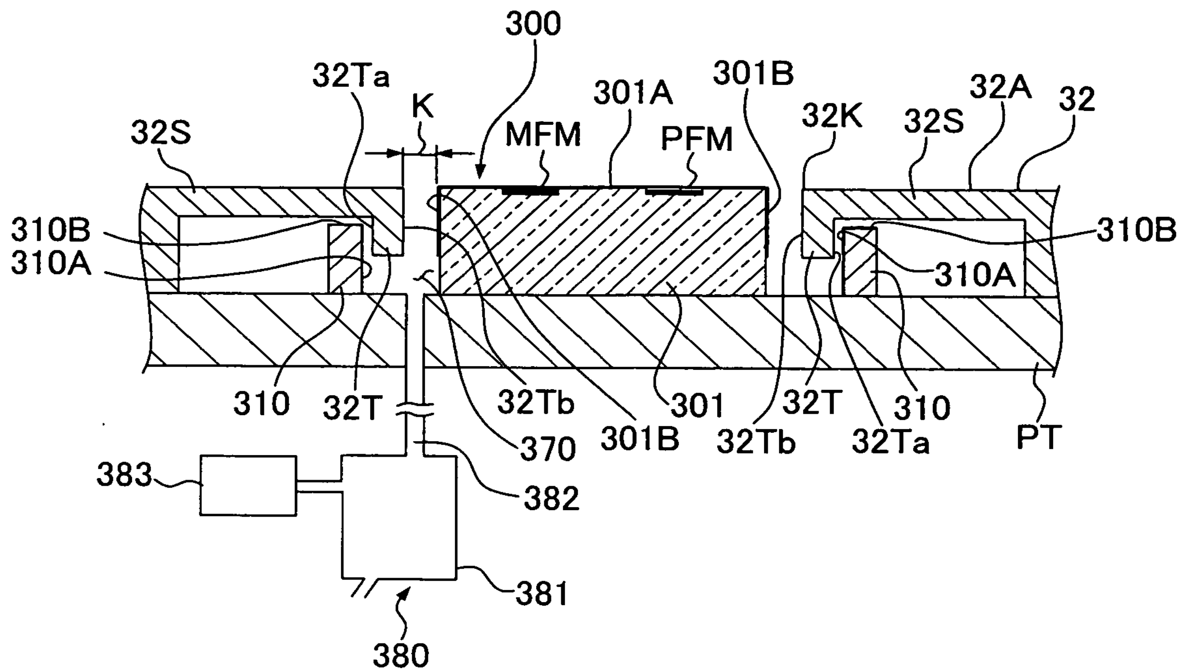
(b)


PH
151
161
162
P
161
162
161
162
150
162
161
162
161
161
162
162
161

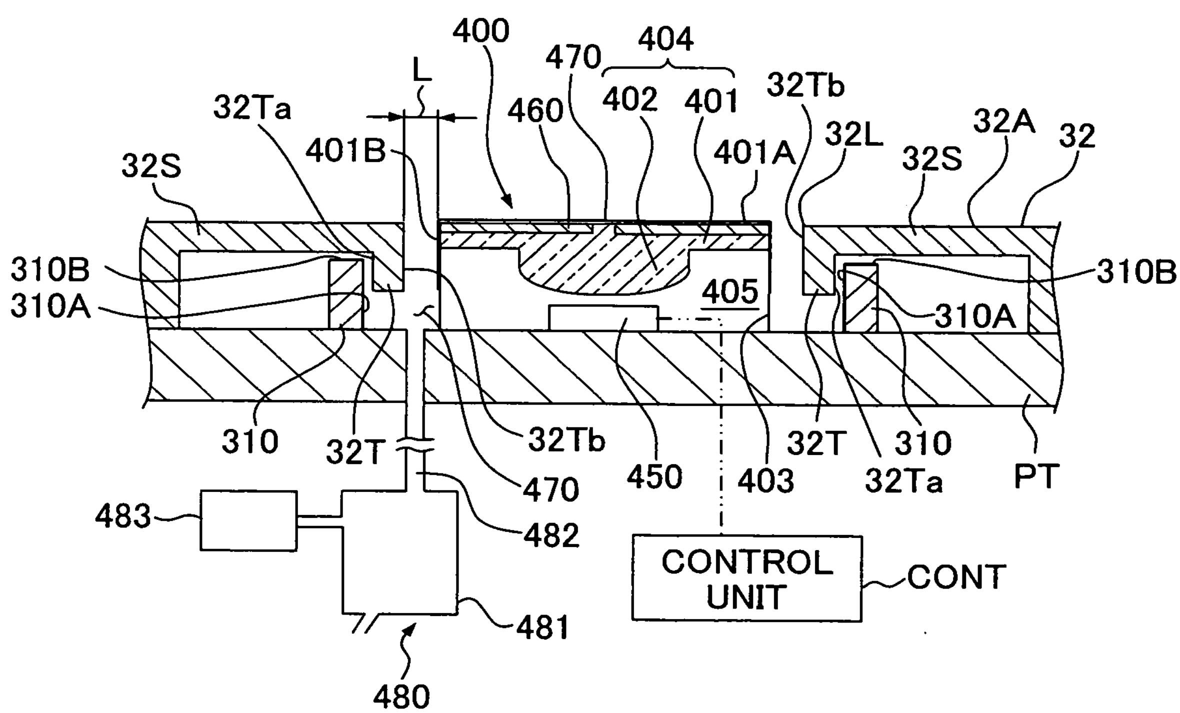
【Fig. 13】


(a)
161
P
161
30A
151
PH
IMPORT
80
157
PT
PST
(b)
P
161
161
161
30A
151
PH
157
PT
PST
(c)
EL
PL
1
30A
151
P
PH
157
PT
PST
AR2
(d)
P
30A
151
PH
EXPORT
80
157
PT
PST

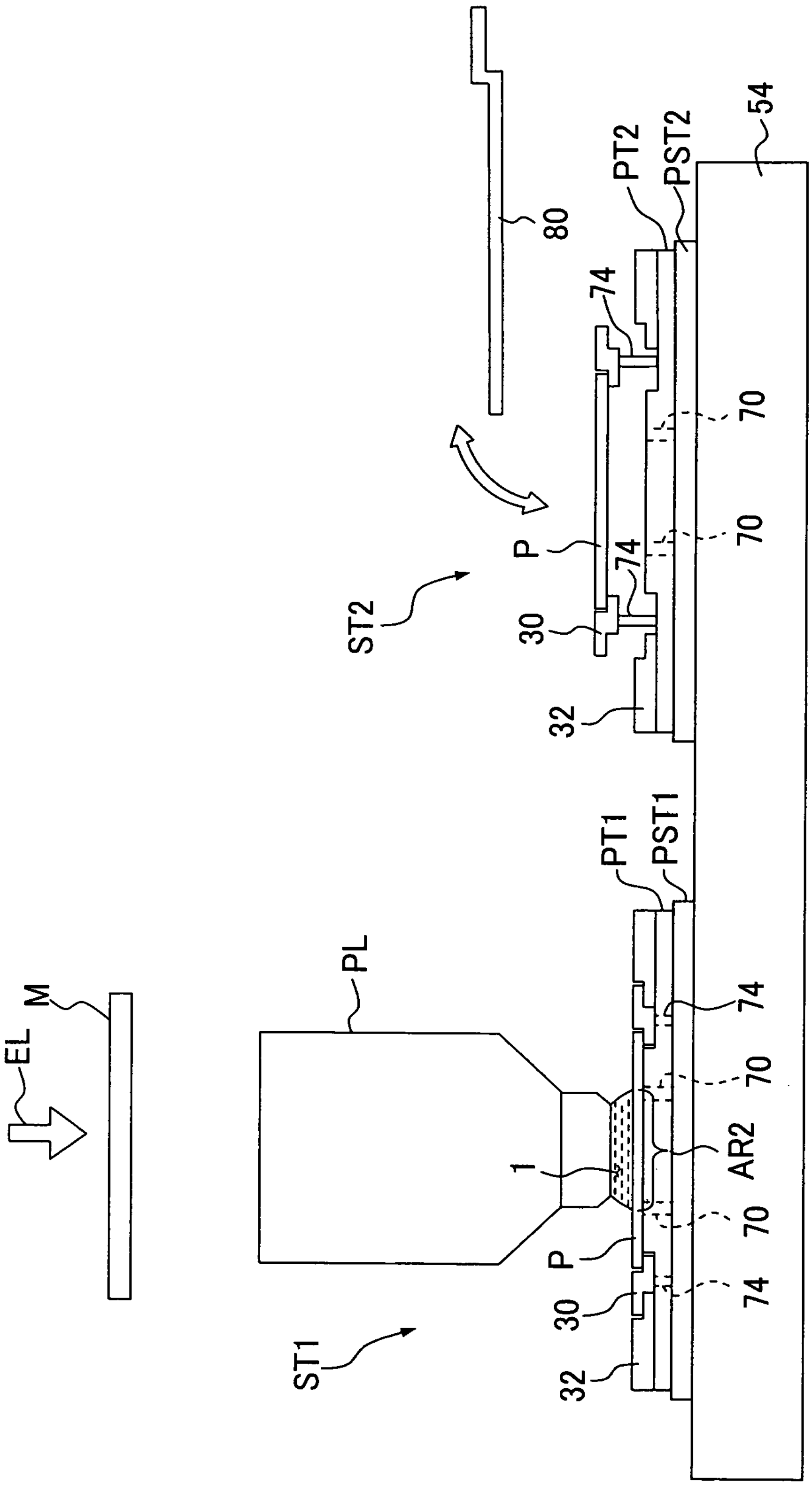
【Fig. 14】


300
32Ta
K
301A
301B
MFM
PFM
32K
32S
32A
32
32S
310B
310A
310B
310A
310
32T
32Tb
301
32T
310
370
301B
32Tb
32Ta
PT
383
382
381
380

【Fig. 15】

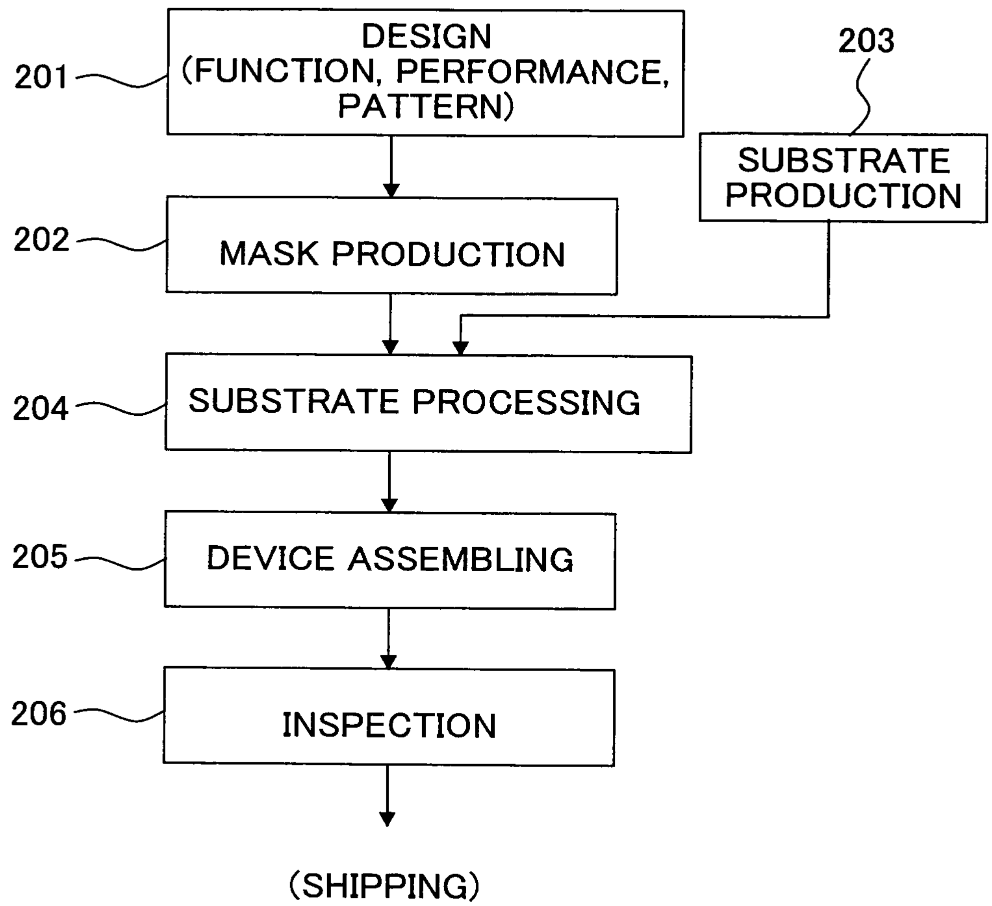

400
404
470
L
402
401
32Tb
32Ta
460
401B
401A
32L
32A
32
32S
32S
310B
310B
405
310A
310A
310
32T
32Tb
450
403
32T
310
470
32Ta
PT
483
482
CONTROL UNIT
CONT
481
480

【Fig. 16】



EL
M
PL
1
ST1
32
30
P
74
70
AR2
70
74
PT1
PST1
ST2
32
30
P
74
70
70
74
80
PT2
PST2
54

【Fig. 17】


201
DESIGN (FUNCTION, PERFORMANCE, PATTERN)
202
MASK PRODUCTION
203
SUBSTRATE PRODUCTION
204
SUBSTRATE PROCESSING
205
DEVICE ASSEMBLING
206
INSPECTION
(SHIPPING)

【Fig. 18】